CRETACEOUS STRATIGRAPHY OF NORTHEASTERN FRONT OF DAVIS MOUNTAINS, JEFF DAVIS COUNTY, TEXAS

by

JESSE LEE BRUNDRETT, B. S.

Presented to the Fac [redacted]

The University of T [redacted]

of the [redacted]

For the Degree of

Master of Arts

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THE UNIVERSITY OF TEXAS
JANUARY, 1955

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THESIS

Presented to the Faculty of the Graduate School of

The University of Texas in Partial Fulfillment

of the Requirements

For the Degree of

Master of Arts

THE UNIVERSITY OF TEXAS

JANUARY, 1955

To

My wife and her mother,

each of whom in her own way

contributed much.

CRETACEOUS STRATIGRAPHY OF NORTHEASTERN FRONT OF DAVIS MOUNTAINS, JEFF DAVIS COUNTY, TEXAS

Jesse Lee Brundrett

A B S T R A C T

The total thickness of the exposed Cretaceous rocks is 1,400 feet. The oldest formation, the *Kent Station limestone of Georgetown age, and the overlying Buda limestone form extensive outcrops; the overlying marls and limestones of Eagle Ford, Austin, and Taylor age are sporadically exposed in small isolated outcrops.

The thick-bedded Buda limestone is subdivided into three members by means of a median layer of sandstone; the Boquillas, into two members. A rich ammonite fauna from the Boquillas formation, including several new species of Forbesiceras and Coilopoceras, permits a tentative partial zonation, a correlation with the zones of the type Eagle Ford, and the tentative placing of the Cenomanian-Turonian boundary near the top of the lower, flaggy member.

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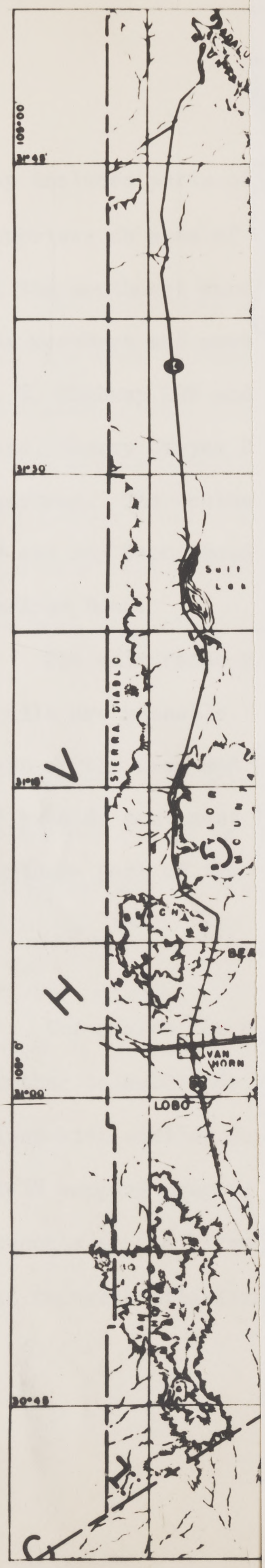
INTRODUCTION

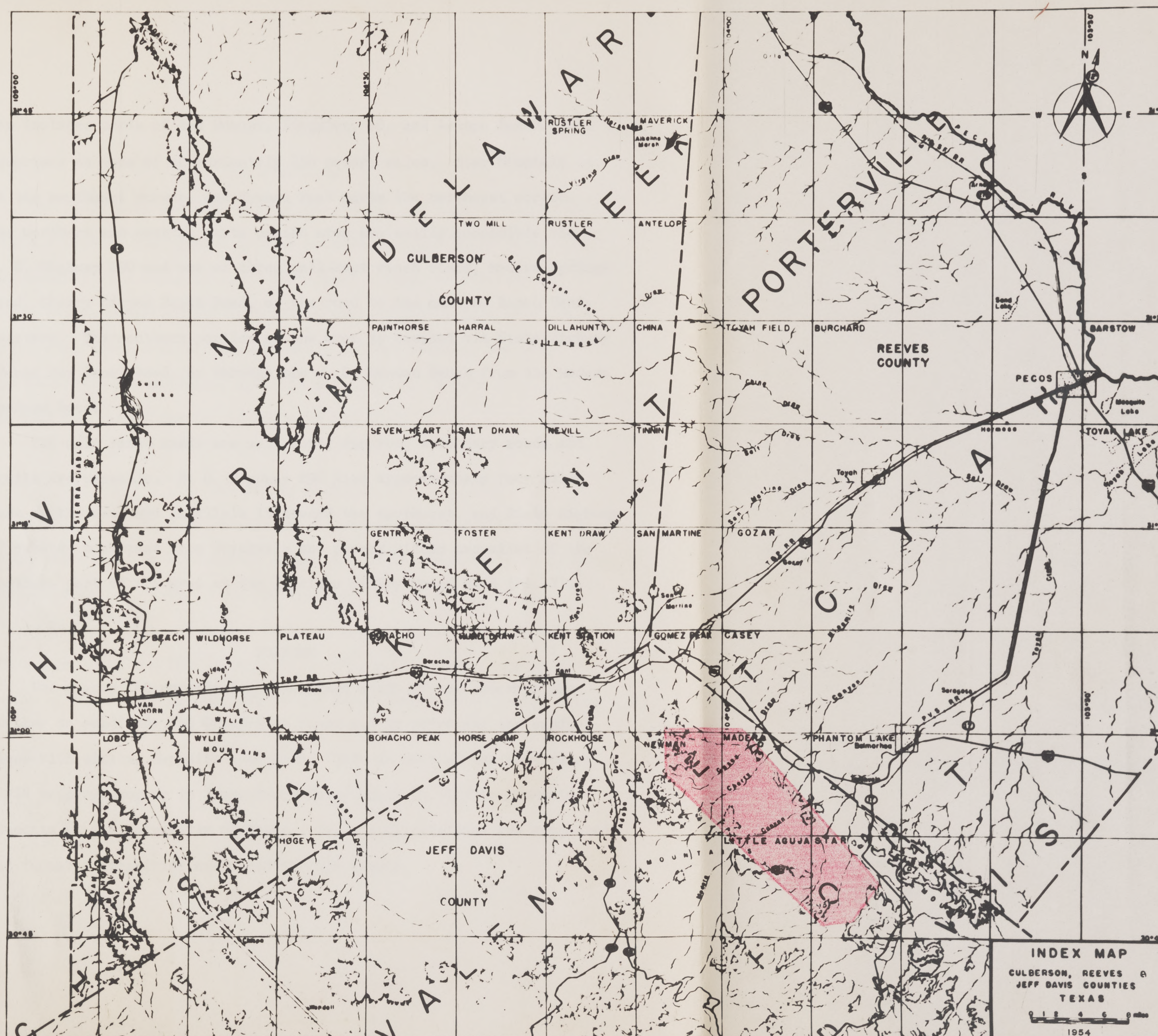
Few areas offer the variety and complexity in geology that is afforded by Trans-Pecos Texas. In this region west of the Pecos River are outcrops of all systems from Precambrian to Recent, including intensely folded and faulted Paleozoic formations. In the Davis Mountains the field geologist may study gently dipping, marine calcareous rocks of the Cretaceous, or he may choose to spend his time mapping lava flows of the Tertiary.

The mapped area presents varied and interesting problems of stratigraphy and structure of Cretaceous limestones and marls, Tertiary volcanic rocks, and Quaternary gravels. The subject of this thesis is the stratigraphy of the Cretaceous outcrops; it is based primarily on faunas, chiefly ammonites collected from Upper Cretaceous formations. The subsurface Cretaceous is not described. The general geology and Cenozoic stratigraphy of the mapped area is the subject of a thesis by the writer's field partner (Wheeler, 1955).

LOCATION

The mapped area (Pl. II) lies along the northeastern front of the Davis Mountains between 30° 46' and 31° 02' north latitude and 103° 48' and 104° 05' west longitude. Paralleling the Jeff Davis-Reeves county line in northern Jeff Davis County, the southern edge of this area is approximately sixteen miles by road southwest of Balmorhea, Texas, and the northern edge is twelve miles southeast of Davis Mountain Station. The


31°45'
31°30'
31°15'
31°00'
30°45'
SIERRA DIABLO
VAN HORN
LOBO



DELAWARE
CHERRY
PORTERVILLE
RUSTLER SPRING
MAVERICK
TWO MILL
RUSTLER
ANTELOPE
CULBERSON
COUNTY
PAINTHORSE
HARRAL
DILLAHUNTY
CHINA
TOYAH FIELD
BURCHARD
BARSTOW
REEVES
COUNTY
PECOS
TOYAH LAKE
SEVEN HEART
SALT DRAW
NEVILL
TINNIN
GENTRY
FOSTER
KENT DRAW
SAN MARTINE
GOZAR
BEACH
WILDHORSE
PLATEAU
BORACHO
KENT STATION
GOMEZ PEAK
CASEY
VAN HORN
LOBO
WYLIE MOUNTAINS
MICHIGAN
BORACHO PEAK
HORSE CAMP
ROCKHOUSE
NEWMAN
MADERA
PHANTOM LAKE
HOGEYE
JEFF DAVIS
COUNTY
LITTLE AGUJA
STAR
N
W
E
S
INDEX MAP
CULBERSON, REEVES &
JEFF DAVIS COUNTIES
TEXAS
1954

PLATE I

map includes parts of the Duncan, Kingston, KC, and Lethco Ranches and comprises an area of approximately 150 square miles. Star Mountain is at the southeast corner, and Newman Peak marks the northwest corner. The northern and central parts of the area are easily accessible via U. S. Highway 290 and one of three well-kept ranch roads, Madera Springs Road, Cherry Canyon Ranch Road, or the road to the main KC Ranch Headquarters. The southern portion of the area is reached via State Highway 17 and Boy Scout Road, or through the J. C. Duncan Ranch from the Madera Springs Road.

The main ranch roads are well-kept; numerous secondary roads and trails are passable. U. S. Highway 290 lies approximately four miles east of the area and parallels it toward the northwest, and State Highway 17 extends southeast from Toyahvale and passes within two miles of the southern part of the area at the juncture of Boy Scout Road (Pl. I).

PURPOSE

The reason for undertaking a detailed study of the outcrops was further to subdivide the Cretaceous rocks and to correlate the subdivisions with similar deposits elsewhere. This is part of the continuing field mapping program in Trans-Pecos Texas begun in 1948 by graduate students at The University of Texas. Certain correlations are suggested and faunal similarities are cited in this thesis.

PROCEDURE

Field Methods

The field work was done during June, July, and August, 1953. Mapping was done on transparent acetate mounted on Edgar Tobin aerial photomosaics at a scale of 2,000 feet equal 1 inch, or directly on United States Department of Agriculture stereoscopic prints at a scale of 4 inches equal 1 mile. A hand level, Brunton compass, and steel tape were used for measuring sections and mapping. A 1946 Army jeep was used for transportation to and from the field.

Laboratory Methods

Fossils collected by Wheeler and Brundrett were identified by the writer and placed in a permanent collection at the Department of Geology, The University of Texas. Over 300 individuals were placed in the collection, of which 200 were ammonites; each speciman has a number, written in India ink (for example UT 10337), and the name, number and source of the fossil is recorded in the departmental paleontology files.

Geologic Map

The geologic map was constructed by transferring data from the field maps onto transparent Kodatrace, correcting for scale and distortion by using triangulation station data from points on the northeast and southwest sides of the area. A land net was prepared from county map entitled, "South Half of Reeves County," published by Southwest Mapping Company, Fort Worth, Texas, and superimposed on the geologic map using data from highway right-of-way plats and section corners located in the field.

Not all the corners located on the ground agree with the same corners as shown on the base map. Along the block line between Blks. 57 and 58, T. 9, T & P RR Co. Survey, the KC Ranch has marked section corners with copper discs set in concrete posts. The location of these marks is indicated on the map (Pl. II), to show the discrepancy between them and the assumed land net.

ACKNOWLEDGMENTS

The writer wishes to express his gratitude for the aid and suggestions received while preparing this thesis. It is with pleasure that thanks are extended the following persons: Professor Ronald K. DeFord, The University of Texas, for supervising the field work and for helpful suggestions in preparing the paper; Professor John B. Brand, Texas Technological College at Lubbock, for field supervision; Professor Sam P. Ellison who served on the writer's thesis committee; Messrs. Jim Duncan, J. C. Duncan, Duncan Kingston, Joe Rounsaville, and Nelson Lethco for permission to work on their ranches; and to Edgar Tobin Aerial Surveys, San Antonio, Texas, who furnished the aerial photographs.

Special thanks are due Professor Keith P. Young, who guided the writer in identifying and photographing the fossils, and to Mr. Joe Wheeler, the writer's field partner, for his assistance and suggestions while in the field.

P H Y S I O G R A P H Y

TOPOGRAPHY

The northeastern front of the Davis Mountain plateau is a bold northeastward-trending escarpment that rises some 2,000 feet above the adjacent area to the east. The thick lava flows of this escarpment attain altitudes of more than 6,000 feet above sea level; salient points along the front, such as Star Mountain and Newman Peak, reach elevations of 6,400 feet.

Spread along the base of the lava scarp is an apron of landslide material, which forms high rugged hills separated by deep canyons. The hills are composed of large irregular blocks of lava and thick accumulations of unsorted gravel. The rugged topography and great height make the area inaccessible except on foot or horseback.

Lying below the landslide hills, separated from them by extensive gravel deposits, Cretaceous rocks are exposed as low rounded hills at an elevation of 4,000 feet. Gradually decreasing in altitude, these Cretaceous hills finally merge with the gravel-covered flat to the east at an elevation of 3,500 feet.

The broad downwarp of the Rounsaville syncline is along the eastern border of the area. The volcanic rocks in this trough form high rugged hills and present a sharp contrast to the horizontal layers of the adjacent lowlying area. Bordering these hills on the west and extending as a broad alluvium-filled flat is an area of low relief across which the major streams have built wide floodplains.

In the southern part of the area the monotony of the landslide hills is broken by Little Aguja Mountain which rises as a huge outlier of Star Mountain rhyolite.

DRAINAGE

Except for that portion caught behind artificial dams, all runoff water finds its way into one of several well defined channels. Drainage to the northeast is by way of Garrett, Cherry, Madera, and Little Aguja Draws, and finally into the Pecos River. All the major streams head well up in the mountains and are fed by innumerable small steep-sided tributary arroyas and canyons. After heavy rains these streams arrive at the foot of the mountains as raging torrents, and the banging of boulders can be heard for several miles. On reaching the flats, the water spreads out over wide gravel-covered floodplains, and its forward progress is greatly reduced.

Although no accurate measurements were made, it is noteworthy that after two consecutive days of heavy rains in the mountains during the summer of 1953, water in Madera Draw had not reached the flats. Following its arrival at the foot of the mountains its forward progress was one mile per hour.

During most of the year the stream channels are dry beds of boulders and sand, but after summer rains they carry large quantities of water. Some of them, notably Cherry Draw, flood large areas of farm land north of Balmorhea.

VEGETATION

As a result of slight rainfall, the vegetation of Trans-Pecos Texas is restricted to those types that are adapted to a semiarid climate. On the mountain slopes, where rainfall is greater, wild cherry, Mexican persimmon, juniper and small oaks are fairly common. In many places the higher gravels support a profuse growth of catclaw (*Acacia constricta*; white thorn), creosote bush (*Larrea divaricata*) and, near the mountains, some mesquite.

Locally, outcrops of K80 limestone, which is of Upper Cretaceous age, are densely covered with cedars, catclaw, and creosote bush, and in places, the Buda limestone supports clumps of ocotillo (*Fouquieria splendens*) and a few scattered cedar trees.

Scattered at random over the Neville gravel are spanish dagger (*Yucca torreyi*), pitaya (*Echinocereus stramineus*), tassajillo (*Opuntia leptocaulis*), lechuguilla (*Agave lecheguilla*), sotol (*Dasylirion leiophyllum*), prickly pear (*Opuntia engelmanii*).

TABLE 1

CORRELATION OF CRETACEOUS
SYSTEM OF DAVIS MOUNTAINS
TRANS-PECOS TEXAS

<table>
<tr><th colspan="2">Series</th><th colspan="2">European Stages</th><th colspan="2">NE Front Davis Mts.</th><th>Austin</th><th>Fort Worth-Dallas</th></tr>
<tr><td rowspan="12">Upper Cretaceous</td><td rowspan="8">Gulf</td><td rowspan="4">Senonian</td><td rowspan="2">?</td><td colspan="2">Formation & Member</td><td>Formation</td><td>Formation</td></tr>
<tr><td colspan="2">K100</td><td>Taylor ?</td><td rowspan="4"></td></tr>
<tr><td>Santonian</td><td rowspan="3">K90</td><td>Upper Member</td><td>Taylor ? or Austin</td></tr>
<tr><td>Coniacian</td><td>K90m</td><td>Austin Chalk</td></tr>
<tr><td colspan="2" rowspan="2">Upper Turonian</td><td>Lower Member</td><td>Austin-Eagle Ford ?</td></tr>
<tr><td colspan="2">K80</td><td rowspan="2">Upper Eagle Ford</td><td rowspan="2">Upper Eagle Ford</td></tr>
<tr><td colspan="2">Lower Turonian</td><td rowspan="2">Boquillas</td><td>K75</td></tr>
<tr><td colspan="2" rowspan="5">Cenomanian</td><td>K71</td><td>Lower Eagle Ford</td><td>Lower Eagle Ford</td></tr>
<tr><td rowspan="7">Comanche</td><td rowspan="3">Buda</td><td>Upper</td><td rowspan="3">Buda</td><td rowspan="3">Buda</td></tr>
<tr><td>KC Sandstone</td></tr>
<tr><td>Lower</td></tr>
<tr><td colspan="2">Absent</td><td>Del Rio</td><td>Grayson</td></tr>
<tr><td rowspan="3">Lower Cretaceous</td><td colspan="2" rowspan="3">Upper Albian</td><td rowspan="3">Kent Station</td><td>K50</td><td>Main Street</td><td>Main Street</td></tr>
<tr><td>Nodular</td><td rowspan="2">Georgetown</td><td>Paw Paw Weno Denton</td></tr>
<tr><td>Fossiliferous</td><td>Fort Worth</td></tr>
</table>

C R E T A C E O U S S Y S T E M

*KENT STATION LIMESTONE

Composition and outcrop.- *Kent Station limestone is nomen nudem for that sequence of limestone and marl between the Boracho sandstone below and the Buda limestone above in the vicinity of Kent, Reeves County, Texas (DeFord, 1951). It consists of thin-bedded, unevenly bedded, nodular, yellowish-gray (5Y 7/2) to grayish-orange (10YR 5/7) limestone and marl. These strata are the oldest Cretaceous rocks in the area of the map (Pl. II). Taylor (1952) has reported a thickness of 350 feet in the area immediately north, and has proposed a two-fold subdivision of the *Kent Station into the lower fossiliferous member and the upper nodular member.

The *Kent Station limestone crops out as high, rounded hills in the extreme northern fringe of the area and forms the lower slopes of smaller Buda-capped hills in the northwestern quarter of the area. Its beds dip southward at 5^{o} to 6^{o}, disappearing under younger formations.

Fossiliferous member.- The lower member of the *Kent Station limestone, a semi-nodular, thin-bedded limestone-and-marl sequence with sporadic thick-bedded limestone layers, contains abundant fossils (Taylor, 1952).

In the northern part of the area the upper few feet of the fossiliferous member is exposed only in the deepest draws; therefore, it is not shown on the map (Pl. II). In a section measured on the south side of the road to the Nelson Lethco Ranch, 3.8 feet of this unit is exposed (Unit 1, Measured Section 1); there the lower fossiliferous member consists of hard, medium-bedded, very pale orange (10YR 8/2) to grayish-orange (10YR 7/4), fossiliferous limestone; the contact with the overlying member is placed at the base of an overhanging cliff of nodular limestone.

Nodular member.- The upper nodular member is exposed in many of the draws in the northwestern part of the area; a complete section (Measured Section 1) was measured on the extreme northern edge adjacent to the area mapped by Taylor (1952).

This member consists of hard, nodular, thin-bedded, irregularly bedded, yellowish-orange (10YR 8/6) to grayish-orange (10YR 7/4) limestone and soft, grayish-orange calcareous clay. A total thickness of 192 feet was measured in a composite section on the northern edge of the area (Measured Section 1). Several medium to thick beds of limestone form ledges that can be traced for short distances, but are not persistent enough to be recognized over any great distance. The most prominent ledge (Unit 16, Measured Section 1), which occurs near the top of the member, may possibly be the K50 limestone lentil mapped by Taylor. No attempt was made to differentiate and map these irregular limestone ledges.

In the north bank of Garrett Draw on the Lethco Ranch the lower 30 feet of the nodular member forms a steep, overhanging cliff above a prominent bench cut on the upper beds of the fossiliferous member.

Fig. 1 - Nodular member of *Kent Station limestone overlain by Buda limestone. View looking north. Northwest of sink on KC Ranch. SW$\frac{1}{4}$ Sec. 7, Blk. 57, T. 9, T & P RR Co. Survey (Pl. II).

A similar cliff and bench at the contact of these two units is exposed about a mile south of U. S. Highway 80, west of Kent (Pl. I). The overhanging cliffs afford shelter for goats and sheep at the present time but show signs of having been used by the Indians in earlier days, as animal drawings have been etched on the walls. The lowermost 4-foot section of the member contains shell beds of Gryphaea sp. and abundant echinoids of several genera. The nodular member overlies the fossiliferous member conformably insofar as could be determined in the scanty exposures.

K50 limestone.- The upper 20 to 30 feet of the nodular member is less marly and has been referred to as the K50 lentil by Taylor (1952). Its beds are composed of hard, dense, medium-bedded, yellowish-gray (5Y 7/2), non-clastic limestone, weathering to grayish-orange (10YR 5/7). The yellowish color, derived from iron oxides in the form of limonite, gives the rock a distinctive appearance when seen from a short distance. Slopewash partly hides the thick beds of the K50 limestone in the northern part of the area, but in the bed of Cherry Canyon on the Duncan Kingston Ranch and in the draws northeast of the KC Ranch these beds are well exposed (Measured Sections 2 and 15).

Fossils and correlation.- The nodular member is strikingly similar in composition to nodular limestone beds in the vicinity of Austin which have been called the Georgetown formation. The presence of Turrilites brazoensis Roemer, an ammonite of Main Street age, in the upper 15 feet of this member, the lithic similarity, and the occurrence

Fig. 2 - Nodular member of *Kent Station limestone showing nodular character and thick-bedded ledges of K50 limestone (Taylor, 1952). View looking north. SW$\frac{1}{4}$ Sec. 7, Blk. 57, T. 9, T & P RR Co. Survey (Pl. II).

of other diagnostic fossils indicate that this sequence of rock is equivalent to the upper part of the Georgetown formation of Central Texas.

Moyer (1952, p. 18-23), working in the San Martine Quadrangle, divided the *Kent Station limestone into four members which he considered to be equivalent in age to the Duck Creek, Fort Worth, Weno, and Main Street formations, respectively. Although detailed study and careful collection of fossils probably would reveal that all faunal stages of the Georgetown formation are present, a two-fold subdivision of the *Kent Station limestone is more practical for mapping purposes in the area covered by this thesis.

Fossils collected by Wheeler and Brundrett include:

KIND	Collection No.	SOURCE Unit	SOURCE Measured Section
Cephalopods:			
Cymatoceras sp.	UT 10219	1 7	13 2
Cymatoceras texanum (Shumard)	UT 10227	1	13
Turrilites brazoensis Roemer	UT 10315	7	2
	UT 10221	15 feet below top of nodular member *Kent Station limestone, S side of Rattlesnake Draw.	
Engonoceras sp.	UT 10275	3	1
Echinoids:			
Holectypus planatus (Roemer)	UT 10240	2	1

KIND	Collection No.	SOURCE Unit	Measured Section
Echinoids--Continued:			
Holectypus planatus (Roemer)	UT 10249	10 feet below top of nodular member *Kent Station limestone, NE of Lethco ranch house.	
Enallaster sp.	UT 10244, UT 10252	15 feet below top of nodular member *Kent Station limestone, NE of Lethco ranch house.	
Heteraster sp.	Not numbered	2, 16	1
Pelecypods:			
Trigonia sp.	UT 10243	10 feet below top of nodular member *Kent Station limestone, NE of Lethco ranch house.	
	UT 10251	16	1
Tetragramma sp.	Not numbered	2	1
Hemiaster elegans (Shumard)	Not numbered	Not in measured section	
Pecten (Neithea) texanus (Roemer)	UT 10247	10 feet below top of nodular member *Kent Station limestone, NE of Lethco ranch house.	
		12	1
		1	13
Pecten sp.	UT 10255	10 feet below top of nodular member *Kent Station limestone, NE of Lethco ranch house.	
		2, 11, 16	1
		7	2
		1	13

KIND	Collection No.	SOURCE Unit	Measured Section
Pelecypods--Continued:			
Gryphaea washitaensis Hill	UT 10250	10 feet below top of nodular member *Kent Station limestone, NE of Lethco ranch house.	
Gryphaea sp.	Not numbered	2, 3, 7 6	1 2
Lunatia sp.	UT 10273	20 feet below top of nodular member *Kent Station limestone, NE of Lethco ranch house.	
Protocardia sp.	UT 10276	Not in measured section	
Other pelecypods		2, 9, 11, 14	1
Gastropods:			
Tylostoma kentense (Stanton)	UT 10277, UT 10278	1	13
Tylostoma sp.	UT 10248	10 feet below top of nodular member *Kent Station limestone, NE of Lethco ranch house. 4, 12, 16	1
Nerinea sp.	Not numbered	2	1
Turritella sp.	Not numbered	2	1

The most diagnostic fossil from the fossiliferous member is one individual of Pervinquieria (Leonites) maxima (Lasswitz) (Unit 1, Measured Section 1, Collection No. UT 10337). Adkins (1927, p. 45) has reported the presence of ammonites of this species near Fort Stockton; the containing beds, which he considered to be equivalent to the Fort Worth limestone, are overlain by a massive, rudistid-bearing ledge, his "Middle Cap Rock."

Although the ledge-forming beds (Units 2 and 3, Measured Section 1) overlying the fossiliferous member are not rudistid-bearing in the mapped area, their lithic composition is similar to that of the Middle Cap Rock of the Fort Stockton area. The faunal content, lithic composition, and stratigraphic position indicate that the fossiliferous member is of Fort Worth age.

Fossils collected by Wheeler and Brundrett include:

KIND	Collection No.	SOURCE Unit	Measured Section
Cephalopods:			
Pervinquieria (Leonites) maxima (Lasswitz)	UT 10337	1	1
Mortoniceras sp.	Not numbered	1	1
Cymatoceras sp.	Not numbered	1	1
Echinoids:			
Holectypus planatus (Roemer)	UT 10263, UT 10264	1	1
Enallaster sp.	UT 10261, UT 10267, UT 10269	1	1
Pelecypods:			
Gryphaea sp.	Not numbered	1	1
Clams	Not numbered	1	1
Gastropods:			
Turritella sp.	UT 10260	1	1

KIND	Collection No.	SOURCE Unit	SOURCE Measured Section
Gastropods--Continued:			
<u>Cyprimeria</u> sp.	Not numbered	1	1
<u>Tetragramma</u> sp.	UT 10266	1	1
Other gastropods	Not numbered	1	1

<u>Deposition</u>.- The abundance of shallow-water bottom-dwelling animals indicates that the nodular member of the *Kent Station limestone was deposited under normal neritic conditions. Gayle Scott (1940) has interpreted a neritic habitat as one in which the depth of water is between 20 and 80 fathoms. During deposition the bottom muds must have been continually shifted by currents and waves to produce the nodular character of the sediments. The shallow sea in which the nodular limestone was deposited also received varying amounts of land-derived silt, which now occurs as marl surrounding the limestone nodules and as separate irregular lenses. Occasional prolonged periods in which the sea water was sufficiently quiet and free of silt permitted the deposition of relatively pure non-clastic limestone.

The fluctuating conditions of the sea during *Kent Station time, which resulted in the deposition of alternating non-clastic limestone and calcareous clay, culminated with the deposition of the K50 limestone (Taylor, 1952; Measured Section 1, this thesis). It is postulated that these sediments were deposited on the shelf of an epicontinental sea that bordered a positive area which lay to the north and west.

Although the northern limit of the *Kent Station sea has not been determined, it certainly extended far north of the villages Kent and Boracho, because a thick section of *Kent Station limestone is present in their latitude. Fuqua (1951) reported 515 feet of this unit near Kent, and George (1948) measured more than 300 feet in the Boracho area.

Near the end of *Kent Station time the mapped area began slowly to rise, and a "high" may have existed to the southwest during deposition of the K50 limestone, for this limestone becomes less persistent laterally and increases in marl content toward the south. It is further postulated that the southwestern positive area continued to exist through part of Buda time, with some possible changes in shape and position.

The postulated southwestern "high" may be the first indication of a general elevation of the sea floor that took place following deposition of the *Kent Station limestone.

No rocks of Del Rio age were recognized in the mapped area. The Buda limestone everywhere overlies the *Kent Station formation, and the absence of typical Del Rio may be evidence that this area was at or above sea level for a considerable time subsequent to the deposition of the K50 limestone. A widespread unconformity is present between the *Kent Station limestone and the Buda, although in places the contact between these two formations appears to be conformable (Fig. 3). Whether the absence of Del Rio is owing to non-deposition, to erosion, or to lateral gradation has not been determined; the apparent conformity of the Buda-*Kent Station contact indicates the first is the most valid assumption.

The possibility that a combination of all three processes is responsible for the absence of the Del Rio beds cannot be overlooked.

Fig. 3 - Massive reef of lower limestone member of the Buda in contact with underlying *Kent Station limestone. North bank of draw just south of Bear Wallow Draw, KC Ranch. View looking north. NW$\frac{1}{4}$ Sec. 24, Blk. 58, T. 9, T & P RR Co. Survey (Pl. II).

Fig. 4 - Animal borings in the upper beds of the *Kent Station limestone as exposed in the bed of Cherry Draw. SW$\frac{1}{4}$NE$\frac{1}{4}$ Sec. 29, Blk. 57, T. 9, T & P RR Co. Survey (Pl. II).

BUDA LIMESTONE

At the type locality on Shoal Creek in Austin, Texas, the Buda limestone is a yellowish limestone containing some pink spots. Previous workers have been able to trace rock of similar composition and stratigraphic position into Trans-Pecos Texas, and the name Buda appears many times in the literature denoting a sequence of limestone strata, which is overlain by the Boquillas flags of Eagle Ford age.

Topography and outcrop.- The Buda limestone is exposed in two principal localities within the mapped area. In that portion that lies north of the road into the KC Ranch, the Buda crops out as low rounded hills, occupying the crest of a northward-trending anticline.

Tributaries of Casey Draw have dissected the land surface so as to form long east-west ridges. Along the flanks of the anticline the eastern ends of these ridges are buried in alluvial material of Casey Draw; the western ends are covered by gravel terraces.

Immediately south of the KC Ranch road and northwest of Dry Tank, the Buda limestone dips under alluvial material to reappear approximately two and a half miles farther south on the Duncan Kingston Ranch. This second large outcrop of Buda limestone is also the result of anticlinal folding, and an east-west downwarp of small proportions serves to carry the Buda beneath the surface between the two major outcrops.

The normal plunge of the anticline allows the Buda beds to dip underground about half a mile north of Madera Draw; they are nowhere exposed south of the Madera Springs road.

Composition.- The Buda consists of hard, dense, medium-bedded to thick-bedded, yellowish-gray (5Y 7/2) to very pale orange (10YR 8/2), reefy limestone containing abundant chert in places. This limestone was readily recognized by the presence of the large gastropod *Nerinea volana* (Cragin) in its upper part, and by the marked change in composition as compared to the underlying *Kent Station limestone.

The Buda is the most resistant rock in the area and, on the northwest, forms a cap rock above the *Kent Station limestone. The hard, dense limestone strata of this formation stand out as steep cliffs where streams have exposed fresh material; as a result, the Buda can be recognized from a distance. In the draws northeast of the KC Ranch the basal Buda stands out very distinctly as a prominent bench above the rubble-covered slopes of the underlying *Kent Station formation. The thickness of the Buda is somewhat variable: it is 98 feet on the KC Ranch, and 119 feet at Cherry Canyon on the Duncan Kingston Ranch (Measured Sections 2 and 15). Taylor (1952, p. 29) reported a total thickness of 167 feet.

After considerable reconnaissance of Buda outcrops, it was apparent that this formation could be divided into at least three easily recognizable units. In ascending order they are: a basal reefy member, a calcareous sandstone member and a flaggy member; each of which will be discussed separately.

Lower limestone member.- The basal member of the Buda limestone consists of massive, thick-bedded, reefy, white (N9) to moderate yellow

(5Y 7/6) limestone and is referred to in this paper as the lower limestone member. It contains abundant fossil-shell fragments so small that they can be seen only with the aid of a hand lens. No corals were identified--certainly none were present that could be seen with the aid of a hand lens; some algal material may be present.

Where this reef is well developed in the northern third of the area, it makes an excellent marker-bed for mapping purposes (Fig. 3). The thickness consistently varies from 15 to 20 feet in the northern portion of the area, but in Measured Section 2 on Cherry Draw only 6 feet of this reef is present. This basal member is the most easily recognized part of the Buda in the area; it shows up readily on aerial photographs as a dark line; it is set apart by abrupt vertical changes in composition. Although its southward rate of thinning is high, it can be traced eastward across U. S. Highway 290 for considerable distance. The basal 1 to 2 feet is characteristically stained dark yellowish-brown by limonite.

Outside the mapped area, this reefy section is exposed in small outcrops on the north side of U. S. Highway 80, approximately 3.3 miles east of Davis Mountain Station, and in extensive outcrops east of U. S. Highway 290. The weathered surfaces are characteristically covered with solution pits; some pits are 1 inch in diameter and 2 inches deep.

The contact with the underlying *Kent Station limestone, concordant for the most part, is undulating in places.

The interpretation that this reef is of Buda age was later confirmed by the occurrence of <u>Budaiceras</u> sp. (Unit 8, Measured Section 2) near the

Fig. 5 - Massive ledge of lower member of Buda limestone showing solution pits. View looking north, near head of unnamed draw north of Bear Wallow Draw. NW$\frac{1}{4}$ Sec. 13, Blk. 58, T. 9, T & P RR Co. Survey (Pl. II).

top of the reefy member, and of Turrilites brazoensis Roemer, an ammonite of Main Street age, $2\frac{1}{2}$ feet below the base of the reef (Unit 7, Measured Section 2). In other places, Turrilites brazoensis Roemer has been found less than 15 feet below this reef.

KC sandstone member.- Overlying the lower limestone member is a 5- to 10-foot section of fine yellowish-brown sandstone, herein called the KC sandstone member. The KC member ranges in composition from a calcareous sandstone in southern exposures to a sandy limestone on the northern edge. Although present and continuous in outcrop throughout the northwest quarter of the mapped area, this member is best developed on the hills northeast of the KC Ranch house, where it is a fine to coarse, yellowish-brown, calcareous, fossiliferous sandstone that serves as an excellent key bed (Measured Section 15).

Measured Section 14 (Sec. 46, Blk. C13, PSL Survey) on the extreme northern boundary of the area indicates that laterally the sandy KC member grades abruptly into limestone; probably it is not present very far north of the mapped area, as Taylor (1952) made no mention of it.

Although not traceable continuously toward the east because it is either eroded away or concealed by overlying volcanic rocks, this sandstone member can readily be identified east of U. S. Highway 290, where the Buda again crops out; there, however, the sandstone occurs some 70 or more feet above the lower limestone member.

The contact with the underlying lower limestone member is rather irregular and wavy, showing undulations up to 2 inches deep but no cross bedding or ripple marks. The following is a description of the beds near the contact as seen in Measured Section 2:

Fine calcareous sandstone	4.0 feet
Soft sandstone and siltstone	0.5 feet
Ironstone containing coarse black chert pebbles and shell fragments in lenses	0.2 feet
Lower limestone member	

The grading of this member northward into limestone and southward into coarser sandstone indicates a source area to the south. The writer postulates that this sandstone records a nearby shoreline of a positive area, possibly an island, in the early Buda sea; yet, such an island was probably not the source of the sand. The general depositional conditions are discussed in a later section.

Petrography of KC sandstone.- Below is a petrographic analysis by Robert L. Folk, The University of Texas, of KC sandstone collected from north side of Garrett Draw north of the Lethco ranch house.

Texture.- Homogeneous, packing looser than normal due to cement spreading the grains; extreme range of grain size .01 mm. to 1.0 mm. - 80% range .07 mm. to .15 mm.; very well sorted; larger fragments are fossils which show good grain orientation.

Mineral composition.- Quartz: 60%; maximum grain size .17 mm.; low sphericity; angular to subangular; grains unattacked by calcite and without overgrowths; most have straight extinction, a few undulose;

inclusions rare; weakly oriented parallel to the bedding; granite most probably source with a few grains derived from metamorphic rocks.

Chert: absent

Feldspar: absent

Metamorphic rock fragments: 1% metaquartzite; grain size - .1 mm.

Micas: minute trace of subequal muscovite and biotite; grain size - .1 mm. to .3 mm.

Glauconite: 1%; rounded pellets .08 mm. in diameter.

Collophane: 5%; probably scales or teeth; grain size .1 mm. to .2 mm.; elongated, orientation perfect; little abraded.

Fossils.- 1% to 3%; calcite, broken fragments of brachiopods (?) .3 mm. to 1 mm.; carbonate entoplasts, rounded, subequal, .1 mm. in diameter.

Cement.- 30%; calcite, poikilitic, in patches up to .3 mm. in diameter.

Interpretation.- Source area of low relief, stable, and composed predominantly of granite with a few metamorphic rocks; climate warm and humid; probably a neritic sand; gentle but persistent currents (good orientation but not abraded); probably 5 to 20 miles off shore.

Name.- Calcitic orthoquartzite.

<u>Upper limestone member</u>.- The uppermost of three members of the Buda limestone, including all beds between the KC sandstone member and the Boquillas flags, consists of hard, dense, medium-bedded to thick-bedded, evenly bedded, yellowish-gray (5Y 7/2), non-clastic limestone containing

Fig. 6 - Flaggy weathering of upper member of Buda limestone showing large irregular slabs. View looking north on north bank of Moore's Draw on Duncan Kingston Ranch. SW$\frac{1}{4}$ Sec. 39, Blk. 58, T. 9, T & P RR Co. Survey (Pl. II).

Fig. 6A - Close-up of flaggy weathering of upper member of Buda limestone showing large irregular slabs. View looking north on south side of Moore's Draw on Duncan Kingston Ranch near Jack-a-bar Tank. SW$\frac{1}{4}$ Sec. 39, Blk. 58, T. 9, T & P RR Co. Survey (Pl. II).

abundant Nerinea volana (Cragin) and Pecten roemeri Hill. Well-preserved silicified colonial corals occur abundantly throughout this upper limestone member; Nerinea spp. are found with shell material replaced by silica.

Locally there is much chert; some hillsides northeast of the KC Ranch house are literally chert "fields", the strewn fragments giving the area a reddish-purple color when viewed from a distance. Although some chert occurs throughout the upper member, the greatest abundance is concentrated in the upper 40 to 50 feet. An exposure just south of the main KC Ranch road shows 15 feet of limestone containing dark gray, irregularly-shaped, tuberous chert nodules (Fig. 8); their average length is 6 inches; average thickness, 4 inches.

The upper limestone member weathers out in large rectangular blocks; the dimensions of some faces are 2 feet by 3 feet. The typical field exposure is a surface covered with these rectangular blocks, many of which have dessication cracks and tinajitas in them (Fig. 7). Moreover, these loose blocks give a ringing sound when struck with a hammer, and a characteristic "clanging" sound can be heard when driving across them in a jeep. The susceptibility of the upper member to chemical weathering is further shown by the presence of solution caverns in the upper layers. One such cavern, 25 or more feet deep, that has developed along a joint plane on the south side of Falls Canyon, is marked by a rock cairn (Sec. 6, Blk. 57, T & P RR Co. Survey, Pl. II). Old settlers report that the remains of several Indians were found in this cavern.

Fig. 7 - Close-up of upper member of Buda limestone showing solution pits due to weathering. SW$\frac{1}{4}$ Sec. 6, Blk. 57, T. 9, T & P RR Co. Survey (Pl. II).

Fig. 8 - Large chert nodules in upper member of Buda limestone. View taken in east bank of draw approximately a quarter of a mile east along fence from six cottonwood trees on main KC Ranch road. Near two cottonwood trees and a metal water tank. SW$\frac{1}{4}$ Sec. 24, Blk. 58, T. 9, T & P RR Co. Survey (Pl. II).

Depressions, or "sinks", in the surface of the upper member are locally present in several places in the area. Circular in outline and bounded by a sharp rim, these features appear to be the result of sinking brought about by the collapse of cavern roofs. They range in size from a few feet to several hundred feet in diameter and contain several feet of dark gray alluvium. One such sink, on the draw south of Rattlesnake Draw, the largest in the area, is 20 feet deep and more than 500 feet across. This draw probably owes its existence to sinks, for it connects a series of them.

The upper beds of the upper member are extensively fractured by jointing; though present in widely scattered areas, the joints are best developed on the hills southwest of the Nelson Lethco Ranch. There the major joint system trends N 50° W with a secondary set at right angles or N 40° E. The rocks have parted along joint planes leaving wide gaps which have become filled with soil (Fig. 9). Because of the softer material and the presence of water, vegetation is concentrated along these fractures in long straight rows, exhibiting a characteristic appearance on aerial photographs.

The upper member ranges in thickness from 75 feet on the north to 104 feet on the south along Cherry Draw. It is separated from the overlying Boquillas flags by a well-defined disconformity (Fig. 10).

Fossils and correlation.- The resistance of the Buda limestone to chemical decomposition precludes the weathering out of much fossil material. Cross sections of gastropods and pelecypods are abundant; the

Fig. 9 - Joints in upper member of Buda limestone. View looking north into north bank of Rattlesnake Draw. NW$\frac{1}{4}$ Sec. 11, Blk. 58, T. 9, T & P RR Co. Survey (Pl. II).

Fig. 10 - Basal part of the K71 limestone member showing contact with underlying Buda limestone. View looking east in east bank of small draw east of KC Ranch house, 200 yards south of main KC Ranch road near two cottonwood trees. SW$\frac{1}{4}$ Sec. 24, Blk. 58, T. 9, T & P RR Co. Survey (Pl. II).

large gastropod *Nerinea volana* (Cragin), which typically occurs in this fashion, is abundant in the middle and upper beds and can be used as a stratigraphic marker. The presence of *Budaiceras* sp. in the top of the lower member helped to establish an interpretation for the lower contact of the Buda. This ammonite, along with *Nerinea volana* (Cragin) and *Pecten roemeri* Hill, was used for the correlation of this formation with other outcrops of Buda age in Trans-Pecos Texas.

Fossils collected by Wheeler and Brundrett include:

KIND	SOURCE		
	Collection No.	Unit	Measured Section
Ammonite:			
Budaiceras sp.	UT 10268	8	2
Gastropods:			
Nerinea volana (Cragin)	UT 10223	12	15
		16, 18, 21	2
Other gastropods	Not numbered	18	2
Pelecypods:			
Pecten roemeri Hill	UT 10220	12	15
		15, 16	2
Gryphaea sp.	Not numbered	6, 18, 20	2
Other pelecypods	Not numbered	18	2
Corals:			
Hexacorals	UT 10361	18, 21	2
Solitary corals	UT 10365	12	15

Deposition.- Perhaps a high which began in *Kent Station time continued to exist during much of Buda time. The existence of this high to the west of the area under study is borne out by the rapid thinning of the members of the Buda in that direction.

By the beginning of Buda time the mapped area had subsided sufficiently to permit the accumulation of biostromal deposits of the lower limestone member. Except for thinning southward, this member is uniform in composition and thickness throughout the mapped area. The writer postulates that possibly the lower member represents an off-shore barrier reef bordering the above-mentioned positive area.

Although this reef directly underlies the KC sandstone member in the mapped area (Pl. II), it is separated from the sandstone by an interval of 70 feet or more east of U. S. Highway 290 (Pl. I). This condition can be explained by rapid growth of the reef basinward in the early stages during which time it was able to maintain its crest at sea level. Soon the depth of water became too great for continued reef development and its growth gave way to the deposition of ordinary limestone. Shoreward, on the other hand, reef growth and increase in depth of water progressed at a much slower rate, allowing the reef to continue to build upward until the deposition of the KC sandstone member occurred. The increase in depth of water seaward can be attributed to one of two causes: either subsidence was more rapid basinward or differential compaction of the underlying rocks allowed more rapid deposition.

The KC sandstone member may represent the seaward extension of a littoral deposit along the shoreline of a Buda high, possibly a large island. The increase in coarseness and purity of this deposit in a southerly direction, plus the thinning of the reef southward, is further evidence for the postulated high which began in *Kent Station time. Although the sediment of the KC sandstone member was a shoreline deposit, it was not derived from the immediate area, for no rocks then exposed in this area could have supplied the arenaceous material.

The presence of dark gray to black chert in the KC sandstone member may indicate that the source area for this unit was to the south in the vicinity of the Marathon Region, but this has not been proven. Assuming that oceanic circulation in the Buda sea followed the same general pattern that it does today in the Gulf of Mexico, it seems quite possible that off-shore currents could have transported sand derived from the Paleozoic rocks on the Marathon uplift and deposited them in the area where the KC sandstone outcrops.

During much of later Buda time the sea must have been relatively quiet and uniform in salinity and temperature to permit the deposition of non-clastic limestone of the upper member. The numerous colonial corals that occur throughout this unit are evidence for uniform temperature and salinity and clearness of water. Large amounts of silica were also introduced into the sea water to produce the abundant chert of the upper levels and silicified fossils that occur throughout the upper member. After examination of a thin section of a silicified Nerinea, Robert L. Folk of the Department of Geology, The University of Texas, remarked that the silica was present as cavity fillings and not as replacement material.

Following deposition of the Buda limestone, the area was elevated above sea level and a long period of erosion began during which the surface of the Buda was extensively altered by channeling. The contact between the Buda and the overlying Boquillas flags is one of marked disconformity along which channels in the Buda have become filled with Boquillas marl.

BOQUILLAS FORMATION

Sedimentary rocks of the Upper Cretaceous series in Trans-Pecos Texas are composed primarily of marl and impure limestone. Thin, flaggy limestone of the Boquillas formation (Adkins, 1932, p. 271), approximately 100 feet in thickness and disconformably overlying rocks of Washita age, are the oldest Gulfian beds in the area. Except for chalky limestone of the K80 formation and K90m member of the K90 marl, the stratigraphic sequence above the Boquillas flags consists of 1,000 feet of thick, orange marl with limestone interbeds. The youngest Upper Cretaceous formation is the K100 shale, which occurs in widely scattered outcrops immediately beneath the Tertiary lavas.

Topography and outcrop.- Although outcrops are scattered in the mapped area, the Boquillas formation can readily be divided into two easily recognized units, the K71 flaggy limestone member and the K75 marl member. The sparse outcrops are susceptible to erosion; they are not an important factor in the topography of the area. As the characteristics and extent of the two members are markedly different, they are more properly discussed separately. An exact thickness is not available, but it is estimated that K71 plus K75 aggregates approximately 215 feet.

K71 limestone member.- Thin, flaggy limestone containing some sand and silt, which overlies the Buda limestone, has been called the Boquillas flags by Udden (1907). Rocks of similar composition approximately 100 feet in thickness will be referred to in this report as the K71 limestone member of the Boquillas formation.

Extensive outcrops of the K71 member are present in the mapped area;

still, many are covered with Quaternary gravels and appear only as thin fringes beneath gravel terraces. Many exposures occur along the flanks of the main anticline, and it is not uncommon to encounter Boquillas flags as one proceeds down the dip slope of a Buda outcrop. Nowhere in the area is an outcrop sufficiently well exposed to permit the measurement of a section with any considerable degree of accuracy, nor to lend itself to a good lithologic description.

The largest outcrop of K71 limestone is on the Duncan Kingston Ranch south of Cherry Draw and near the KC Ranch boundary line (Sec. 32, Blk. 57, T. 9, T & P RR Co. Survey, Pl. II). An extensive area is there composed of K71 limestone, but much of it is covered by Quaternary gravel.

A second outcrop of considerable size is on the KC Ranch just east of Dry Tank and southeast of the main ranch corrals.

A third and much smaller outcrop occurs near Dick Tank approximately two miles north along ranch road from the Duncan Kingston Ranch house and near the distal edge of the landslide apron of the Davis Mountains. The description of the K71 member was obtained from a quarry at this locality.

Except in the outcrops mentioned above, the limestone of the K71 member occurs as patches beneath gravel or as small scattered patches in slight depressions in the Buda limestone. No outcrops of the K71 limestone member occur south of Madera Draw.

The K71 member is composed of thin-bedded, flaggy, impure limestone containing varying amounts of sand and silt interbedded with sandy marl. Both the limestone and marl have a characteristic ferruginous appearance; oxidized iron compounds give them a pale yellowish-orange (10YR 8/6) to dark yellowish-orange (10YR 6/6) hue. The limestone layers range in thickness from a quarter of a foot to two feet, averaging about one foot.

The surface of a typical exposure of K71 member is covered with small irregular flags up to 6 inches by 8 inches; limonite nodules are abundant. In many places the first indication of an exposure of K71 limestone nearby is a profusion of limonite nodules scattered on the exposed surfaces of the Buda limestone. Characteristically the K71 outcrop shows spurious high-angle dips, some of them nearly 90 degrees. This condition makes it impracticable to measure significant dips. Nowhere in the area is this unit sufficiently well-exposed to warrant measuring a section, and nowhere is top and bottom exposed at the same outcrop. As a result of the poor outcrops, it was not feasible to measure thickness, but it is believed that not more than 100 feet of K71 limestone is present in the mapped area.

Although the complete section is nowhere exposed, two fresh exposures permit a study of the composition of the unit and the nature of the lower contact. In a small draw just south of the main KC Ranch road, a mile west of the main corrals, the lower 10 to 15 feet of the K71 member is exposed (Fig. 10). There the undulating character of the Buda-K71 contact is readily apparent.

The second of the above-mentioned exposures is in the rock quarry on the Duncan Kingston Ranch near Dick Tank (Sec. 45, Blk. 58, T. 9, T & P RR Co. Survey, Pl. II), in the walls of which typical flaggy K71 limestone is excellently exposed. The following is a description of the rock exposed in the north wall:

> Limestone, hard, silty, thin- to medium-bedded, evenly bedded, pale yellowish-orange (10YR 8/6) to dark yellowish-orange (10YR 6/6) interbedded with thin laminated yellowish-orange marl partings; marl contains abundant limonite nodules and concretions; average thickness of limestone beds 1 foot, thickness of marl beds average 6 inches.

Much of the weathered K71 limestone contains a coating of secondary caliche, and in places rather unusual local structural features have been formed as a result. At the west end of the quarry on the Kingston Ranch a classic example of secondary deformation due to caliche is exposed. Internal solution and swelling inherent with the formation of caliche has so arched the thin, calcareous marl layers that the bed at apex of fold is approximately 1.5 feet higher than its normal position. There appears to have been a buckling or swelling in the limestone layers causing them to arch. Three well defined, successive layers of limestone and marl show this arching effect. It would appear that arching continued until strain on the beds became so great that they parted, for a break is apparent at the apex of the folds in one of the beds. Downward percolating surface water permeating 5 or 6 feet below the surface is

Fig. 11 - Typical Buda-K71 contact. View looking northwest. South of Cherry Canyon Ranch road near Duncan Kingston-KC Ranch boundary. SW$\frac{1}{4}$ Sec. 33, Blk. 57, T. 9, T & P RR Co. Survey (Pl. II).

probably responsible for the formation of caliche. The clay content of these beds is high, and clays reacting with water at this depth tend to cause an upward swelling; owing to less resistance overhead than below, upward buckling resulted in the peculiar folding of the marl and limestone beds. This effect is apparent in other places in this outcrop, but the best example is the one described.

The contact of the K71 limestone member with the overlying K75 marl member is transitional.

K75 marl member.- The few outcrops of the K75 marl member are scattered. Only three are worthy of mention: the outcrop at Dry Tank on the KC Ranch, the outcrop at the west end of a high gravel terrace southeast of the KC Ranch headquarters, and the outcrop near a steel tank and windmill northeast of KC headquarters. Sections were measured at Dry Tank (Measured Section 4) and at the base of the high gravel terrace (Measured Section 5) (NW$\frac{1}{4}$ Sec. 30, Blk. 57, T. 9, T & P RR Co. Survey, Pl. II).

The K75 member consists of friable, thick-bedded, dark yellowish-orange (10YR 6/6) to pale yellowish-orange (10YR 8/6) marl with thin, chalky limestone interbeds.

Although K75 outcrops are few, the marked change in composition and the presence of abundant large ammonites distinguish this part of the formation from the underlying K71 limestone member. Previous workers have recorded a scarcity of fossils in the Boquillas formation.

Two of the existing outcrops of K75 marl are at the base of

Quaternary terraces and owe their presence to the terraces. The susceptibility of the marl to erosion and deep weathering results in most outcrops being rapidly destroyed or covered. The dark yellow color of the marl is derived from iron oxides in the rock itself; while it is helpful in giving outcrops a distinctive orange hue when viewed from a distance, it also leads to confusion with the younger yellowish marl of the K90 formation.

A total thickness of 155 feet of this marl was measured at Dry Tank, whereas in Measured Section 5 only 118 feet was measured. These sections are only 2 miles apart; the difference in thickness can be attributed to errors in measurement in Measured Section 4. It was necessary to measure by the angle of dip and calculate thickness from horizontal distance; but the dips obtained from the weathered limestone beds are unreliable. The measurement of 118 feet is probably the more nearly correct.

The contact of the K75 marl member with the overlying K80 chalky limestone is transitional.

Fossils and correlation.- Ammonites are abundant in both the K71 limestone member and the K75 marl member, and preservation is unusually good.

The fauna of the Boquillas formation is readily divisible into two faunules, each of which is characteristic of its enclosing rock unit. The K71 limestone member contains mostly small, tenuous ammonites, whereas very large, obese forms are abundant in the K75 marl member. Collecting was done at two localities in this area, one of which yielded excellent silicified material. On the Duncan Kingston Ranch south of Cherry Draw, where the Boquillas-Buda contact is exposed, reddish-brown ferruginous sandstone fragments are strewn over the Buda surface along the down-dip fringe of a large K71 outcrop, which yielded excellently preserved ammonites of several genera (Fossiliferous locality 1). Individuals of the small smooth ammonite Phylloceras are abundant there; several bizarre forms of Turrilites and several species of Forbesiceras were collected.

Fossils collected by Wheeler and Brundrett from Fossiliferous locality 1, NW$\frac{1}{4}$ Sec. 33, Blk. 57, T. 9, T & P RR Co. Survey (Pl. III and IV):

KIND	Collection No.
Ammonites:	
Forbesiceras sp. "A" n.sp.	UT 10279, UT 10282, UT 10734
Forbesiceras sp. "B" n.sp.	UT 10334, UT 10735, UT 10737
Forbesiceras n.sp.	UT 10283, UT 10736
Turrilites sp. aff. T. tuberculatus	UT 10280
Turrilites sp. "A" n.sp. ?	UT 10738
Turrilites sp. aff. T. bergeri ?	UT 10286, UT 10287, UT 10288
Turrilites n.sp.	UT 10289
Phylloceras sp. ?	UT 10328, UT 10330 to UT 10332 Inc.
Gastropods	Not numbered
Pelecypods	Not numbered

Aside from their excellent preservation, some of these fossils are interesting for their close resemblance to European forms of the same age; W. S. Adkins (oral communication, 1954) remarked that the turrilitids closely resemble species that he has seen in Europe.

In the lower part of a section measured at Dry Tank (SW$\frac{1}{4}$ Sec. 20, Blk. 57, T. 9, T & P RR Co. Survey, Pl. II) the upper 15 feet of the K71 limestone is present. A zone 5$\frac{1}{2}$ feet thick yielded the following fossils (all from Measured Section 4):

KIND	Collection No.	Unit
Ammonites:		
Acanthoceras sp. aff. *A. pentagonum* (Brown & Hill)	UT 10242	1
Acanthoceras sp.	UT 10291	2
Calycoceras spp.	UT 10258, UT 10259	1, 2
Metoicoceras irwini Moreman	UT 10257	2
Metoicoceras whitei	UT 10231	3
Metoicoceras sp. aff. *M. swallovi*	UT 10246	2
Metoicoceras sp.	UT 10256	1
Metoicoceras sp. aff. *M. whitei*	UT 10293	1
Pelecypods:		
Inoceramus labiatus (Schlotheim)	UT 10368, UT 10370	4, 6
Inoceramus sp.	Not numbered	4

The fauna of the K71 limestone member closely resembles that of the lower part of the Eagle Ford shale of Central Texas. As *Forbesiceras* sp.

and Turrilites sp. have been reported from the base of the Eagle Ford in Dallas County (Adkins & Lozo, 1951), the presence of these forms in Trans-Pecos Texas indicates that the Gulfian sea began transgressing the land area over widely separated areas of Texas at much the same time. Inasmuch as several authors have zoned the Eagle Ford rocks of Central Texas on the basis of fossils, it seems worthwhile to point out some of the similarities in the faunas of the two widely separated areas.

Adkins and Lozo (1951) have divided the Eagle Ford into nine faunal zones (Table 2). The basal part of the K71 member appears to be correlative with their zone 1 in which they report Forbesiceras and Turrilites. Their zone 4 in the Waco area contains Acanthoceras sp., Calycoceras sp. and Metoicoceras sp.; these genera were collected by the writer from the upper 3½ feet of the K71 member. Whether zone 2 and zone 3 are present in the mapped area cannot yet be answered, but apparently the upper part of the K71 limestone member is equivalent to zone 4 of Adkins and Lozo.

Moreman (1942) has placed Metoicoceras irwini Moreman, Metoicoceras whitei, and Metoicoceras swallovi in his zones 2, 3, and 4, basing a separate zone on each specie, whereas along the northeastern front of the Davis Mountains these three species occur in a single zone only 3½ feet thick.

The following tentative zoning of the K71 limestone member has been recognized in the mapped area (Table 2):

Moreman (1942)
North Central Texas

Zone	
9	Eagle Ford, Austin Cl Transgression
8	Prionotropis woolgari
7	Gauthiericeras aff. b
6	Metoicoceras gibbosum
5	Helicoceras pariense
4	Metoicoceras swallovi
3	Metoicoceras whitei
2	Metoicoceras irwini
1	Acanthoceras aff. rot

TABLE 2

EAGLE FORD ZONATION

Zone	Moreman (1942) North Central Texas	Zone	Adkins & Lozo (1951) Waco, Texas, Area	Zone	Brundrett (1954) Northeastern Front
9	Eagle Ford, Austin Chalk, Transgression	9	Alectryonia lugubris		
				K80a	Prionocyclus sp.
8	Prionotropis woolgari	8	Coilopoceras austinense-Coilopoceras n.sp.-Prionocyclus sp.	K75c	Coilopoceras
				K75b	Collignoniceras
7	Gauthiericeras aff. bravaisi	7	Coilopoceras eaglefordense	K75a	Fagesia
6	Metoicoceras gibbosum	6	Metaptychoceras-Worthoceras-Romaniceras		
5	Helicoceras pariense	5	Neocardioceras		
4	Metoicoceras swallovi	4	Eucalycoceras bentonianum-Mantelliceras n.sp.	K71c	Metoicoceras
				K71b	Calycoceras-Acanthoceras
3	Metoicoceras whitei				
2	Metoicoceras irwini				
				K71a	Forbesiceras
1	Acanthoceras aff. rotomagenes				

Zone		Thickness Feet
K71c	Metoicoceras zone	3.5
K71b	Calycoceras-Acanthoceras zone	2.0
K71a	Forbesiceras zone	Not determined

This is not a formal proposal, but it is rather intended as a base on which future students may expand. Much additional detailed work will be necessary to establish the lateral extent of the fauna and to determine the extent to which individual genera are restricted vertically over wide areas.

The fossil assemblage of the K71 limestone member establishes its age as Cenomanian, for these species of Metoicoceras, Forbesiceras, and Acanthoceras are exclusively Cenomanian types (Keith Young, oral communication, 1954), many of which are closely related to forms of the same age in Europe.

Adkins (1932, p. 437) has made the following statement:

> It is noteworthy that in the English and French sections the Cenomanian-Turonian boundary is marked by a zone of Neocardioceras and Metoicoceras pontieri (aff. irwini Moreman).

Although Neocardioceras was not found, Metoicoceras irwini Moreman in zone K71c of this paper may mark the top of the Cenomanian.

Although the writer has placed Metoicoceras irwini Moreman and Metoicoceras whitei within a single faunal zone, they do occur in different units of Measured Section 4, and further collecting may prove that they should correctly be placed in separate zones (cf. the following excerpt from Measured Section 4):

Unit		Thickness Feet
3	Marl . . . containing Metoicoceras whitei . .	2.8
2	Limestone . . . containing Metoicoceras irwini Moreman....................................	0.7

Adkins (1931, p. 71) has stated:

> Spath's zones clearly indicate the Lower Turonian age of Metoicoceras whitei . . .

If this is correct, the Turonian-Cenomanian boundary may lie between Units 2 and 3 of Measured Section 4. Additional collecting to determine the vertical ranges and presence or absence of additional genera is necessary to place the boundary accurately.

The ammonites of the K75 marl member are abundant and occur throughout the section, but they seem to be rather more plentiful in the limestone layers within the marl. Only three genera were collected from Measured Section 4, but each seems to occupy a separate and distinct interval. These three intervals, which will be referred to as zones K75a, K75b, and K75c of the Boquillas formation, are distributed vertically as follows (Table 2):

Zone			Thickness Feet
	Limestone and marl	No ammonites	26
K75c	Marl	Coilopoceras zone	64
K75b	Marl	Collignoniceras zone	24
	Marl	No ammonites	6
K75a	Marl	Fagesia zone	32

A single individual, Fagesia pervinquieri, was collected from zone K75a, but since no other fossils were found in this zone and Fagesia was not found higher, it seems probable that this form is restricted to the basal part of the K75 marl member. Adkins (1931) has reported finding Fagesia sp. in the Van Horn Mountains in a zone which he correlates with the basal part of his Chispa Summit formation and considers to be of Lower Turonian age.

Zone K75b, which yielded several species of Collignoniceras and a single Coilopoceras, may be transitional to the Coilopoceras zone.

The greatest profusion of ammonites occurs in zone K75c, which yielded several species of Coilopoceras and a single individual of Prionocyclus. This zone has been recognized at Chispa Summit, in the condensed zone (Adkins, 1931) at Austin, Texas, and in Moreman's section in North Central Texas. The genus Coilopoceras is everywhere regarded as of upper Turonian age, and the Coilopoceras zone is the most widespread of the faunal zones of Eagle Ford age in Texas.

The K75 marl member is certainly correlative with the lower part of the Chispa Summit formation in western Jeff Davis County, Texas, and with Taylor's (1952) "marly facies" of the Boquillas formation. Faunally the K75 marl member would appear to be the western equivalent of the upper part of the Eagle Ford shale of Central Texas.

In connection with a discussion of the relative age of the K71 and K75 members, a statement by Adkins (1949) is noteworthy:

Upper Eagle Ford Shales . . . This and the condensed zone contain exclusively Turonian fossils; the underlying limestone flag member contains exclusively Cenomanian fossils.

Much the same situation exists at Dry Tank (Measured Section 4).

That the boundary between Turonian and Cenomanian stages is to be found at the base of the K75 marl member seems quite possible, since good Cenomanian ammonites occur 10 feet below the base of the K75.

Fossils collected by Wheeler and Brundrett include:

KIND	Collection No.	SOURCE: Unit	SOURCE: Measured Section
Ammonites:			
Coilopoceras springeri (Hyatt)	UT 10228	11	4
Coilopoceras cf. austinense Adkins	UT 10229	8, 10, 11, 12	4
	UT 10237	Fossiliferous locality 3	
Coilopoceras n.sp. "hazzardi" Adkins	UT 10320, UT 10233	11, 12	4
Coilopoceras n.sp.	UT 10232	11	4
Coilopoceras n.sp. aff. C. "hazzardi" Adkins	UT 10234	12	4
	UT 10238, UT 10239	Fossiliferous locality 3	
Coilopoceras sp.	Not numbered	11, 12	4
Collignoniceras eaglensis Adkins	UT 10236, UT 10335	8, 10	4
Collignoniceras n.sp. aff. C. eaglensis Adkins	UT 10336	8, 10	4
Fagesia pervinquieri (Bose)	UT 10235	5	4
Prionocyclus sp.	Not numbered	12	4

KIND	Collection No.	SOURCE Unit	Measured Section
Pelecypods:			
Inoceramus labiatus (Schlotheim)		5, 6, 8, 10, 13	4
Durania sp.		6, 11	4
Vertebrates:			
Unidentified fish	Not numbered	12	4

Fossiliferous locality 3 is in the SE$\frac{1}{4}$NW$\frac{1}{4}$ of Sec. 23, Blk. 58, T. 9, T & P RR Co. Survey (Pl. II).

Deposition.- Following a period of subaerial erosion, which began at the close of Buda time, the Gulfian sea gradually advanced onto the land of what is now Trans-Pecos Texas. During the early stages, in which erosion was very vigorous, large quantities of land-derived silt, sand, and mud were transported by streams and deposited in this area, indicating a near-shore, shallow-water environment in which the K71 flaggy limestone member was deposited. Uniform distribution of coarse and fine material is the result of vigorous current and wave action. Contemporaneous with the deposition of mud and silt, calcium carbonate and iron compounds were deposited. The thorough mixing of silt and limestone of the K71 member indicates that the calcium carbonate was probably transported as detrital material; still, it is possible that some was precipitated in situ. Probably older Cretaceous limestones elevated above sea level at the close of the Lower Cretaceous epoch were the source of the calcium carbonate in the K71 limestone member.

With the continued advance of the sea during K75 time, the mapped area may have been too far from shore to receive sand and silt, but large quantities of fine mud, transported by currents and waves, were deposited in this area, later to become consolidated into the marl of the K75 member.

K80 LIMESTONE

Topography and outcrop.- The few outcrops of K80 limestone are widely scattered. The most extensive outcrop is on the J. C. Duncan Ranch approximately $2\frac{1}{2}$ miles northeast of Little Aguja Mountain, where low rounded limestone hills rise out of a Quaternary-gravel flat. Smaller outcrops of K80 limestone overlying the K75 marl form a series of hogbacks separated by saddles at Dick Tank, at Dry Tank, near the Jim Duncan Ranch house, and northeast of the KC Ranch house.

Composition.- The K80 limestone is composed of soft, chalky, yellowish-gray (5Y 8/1) to white (N9) fossiliferous limestone interbedded with whitish marl. A complete section 79 feet thick was measured at Dry Tank (Measured Section 4); a partial section in the southern part of the area is 50 feet thick (Measured Section 17). It may not be definitely stated that the K80 limestone and the K90 marl are conformable. In a stream cut west of Dry Tank the contact is slightly undulating; here and there an ironstone layer 1 inch to 2 inches thick occurs at the top of the K80 limestone; and depressions in the top of the K80 limestone, some of them 3 inches deep, are filled with K90 marl. In some outcrops the upper limestone bed of the K80 formation contains abundant bore holes.

In an outcrop south of the J. C. Duncan Ranch house, the contact is transitional, the top of the K80 limestone grading into the overlying K90 marl.

The K80 limestone is best exposed in a cliff face northwest of the Nelson Lethco Ranch house, where a total of 68 feet was measured in

Measured Section 6 (NE$\frac{1}{4}$ Sec. 5, Blk. 58, T. 9, T & P RR Co. Survey, Pl. II).

Fossils and correlation.- Fossils were collected from outcrops at Dry Tank (Fossiliferous locality 2) and northeast of the KC Ranch (Fossiliferous locality 3), but ammonites are present in all outcrops. Several species of Prionocyclus occur in the limestone beds of the K80 formation, but preservation is so poor that identification of species was not attempted.

Early workers in Trans-Pecos Texas incorrectly identified whitish limestone and marl occurring above the Boquillas formation as Austin Chalk. The chalky limestone resembles the typical Austin Chalk exposed near Austin, Texas. In this connection, the following statement from Bose and Cavins (1927) is noteworthy:

> It is very possible that the whitish marls which appear above the Eagle Ford shales in some parts of Texas and northern Mexico and which generally have been regarded as Austin Chalk represent in reality the Upper Turonian.

The presence of several species of the ammonite Prionocyclus fixes the age as Upper Turonian. Taylor (1952) reported Prionocyclus sp. from K80 beds in the vicinity of Davis Mountain Station, at the junction of U. S. Highways 80 and 290 (Pl. I); furthermore, this ammonite was found at some level in every outcrop in the mapped area. Beds in the upper part of the Eagle Ford shale in Central Texas contain Prionocyclus sp. and Collignoniceras sp.; therefore, the K80 limestone is more correctly dated as being upper Eagle Ford in age. The fauna of the K80 limestone is not equivalent to the fauna of the Austin group.

Fossils collected from the K80 limestone by Wheeler and Brundrett include:

KIND	SOURCE Collection No.	Unit	Measured Section
Ammonites:			
Prionocyclus n.sp. ?	UT 10296, UT 10300	1 15	17 4
Collignoniceras sp. Prionotropis woolgari (Meek)	UT 10297	1	17
Prionocyclus sp.	UT 10320, UT 10321 UT 10319	14 14, 15	4 4
Prionocyclus sp. aff. P. wyomingensis (Cobban)	UT 10338	1	17
Nautiloid	UT 10299	1	17
Pelecypod:			
Inoceramus labiatus (Schlotheim)	UT 10489	14	4

K90 MARL

Topography and outcrop.- K90 is nomen nudem for the dark yellowish-orange (10YR 6/6) marl that is irregularly exposed beneath the Tertiary lavas along the northern and eastern front of the Davis Mountains. This yellowish marl has been incorrectly considered as comprising the entire section between the K80 limestone and the Jeff conglomerate. In the mapped area, a chalky limestone member, the K90m member, intervenes; it overlies typical K90 marl and is in turn overlain by the same characteristically yellowish K90 marl. Extensive outcrops of the K90 formation, totaling approximately 825 feet, occur in two vicinities. Along the eastern side of the mapped area, the K90 exposures in the western limb of the main syncline form an almost continuous outcrop from the base of Star Mountain to Washington Tank on the KC Ranch. Here and there the outcrop is obscured by Quaternary fill or covered by gravel. The other vicinity is along the mountain front where another almost continuous exposure exists, except for concealment by landslide material. Where protected by the Tertiary lavas, the K90 forms steep slopes; where unprotected, it forms wide flats which weather deeply unless protected by a cover of recent fill.

Several hundred feet of K90 marl are exposed along the road leading to Old Madera Springs on Madera Canyon, but no measurements were made there.

Lower marl member.- South and west of Little Aguja Mountain, the three members of the K90 formation can be readily recognized. The lower

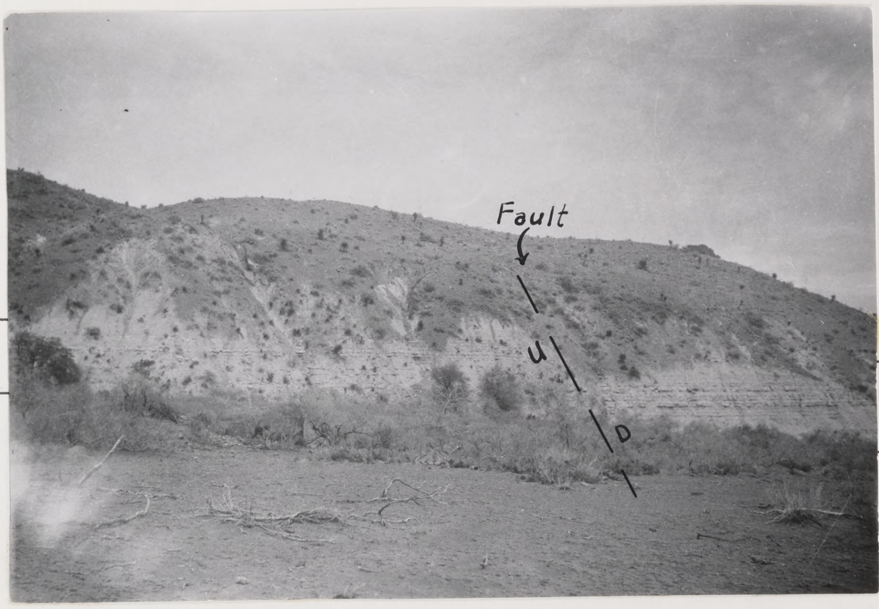


Fig. 12 - K90m chalky limestone member of the K90 formation, showing thick-bedded limestone layers. View looking north into north bank of Little Aguja Creek on the Espy Ranch. SE$\frac{1}{4}$ Sec. 26, Blk. 357 (Pl. II).

Fig. 13 - Upper marl member of K90 formation showing veins of gypsum. View looking south in south bank of small stream west of Washington Tank. SW$\frac{1}{4}$ Sec. 5, Blk. 57, T. 9, T & P RR Co. Survey (Pl. II).

marl member is well exposed at the southern foot of Little Aguja Mountain, where a 250-foot section is overlain conformably by the basal impure limestone ledge of the K90m member. The lower member is composed entirely of thick-bedded, laminated marl, which weathers to a yellowish-orange. No outcrops of the lower member of the K90 marl warranted a detailed description.

K90m chalky limestone member.- It was not until chalky limestone was encountered in landslide material in the southern part of the area that the true relation of the K80, K90, and K90m units was realized. A traverse begun in the flat east of Little Aguja Mountain near good K80 exposures, crossed a long exposure of the lower marl member of the K90 formation; then some landslide material; then a fresh outcrop of whitish chalky limestone 61 feet thick (Measured Section 16). Subsequent work located an outcrop of the K90m limestone member in a creek bank southeast of Little Aguja Mountain, and another outcrop behind the J. C. Duncan Ranch house. The best exposure of the K90m chalky limestone member is in the north bank of Little Aguja Canyon on the Espy Ranch, half a mile north of the road to Boy Scout Camp (Measured Section 7); there the upper contact is visible, and typical K90 marl of the upper marl member is exposed above the K90m limestone member.

The K90m member consists of thick-bedded, evenly bedded, chalky, light gray (N6) to pale orange (10YR 8/2) limestone, interbedded with friable to indurated grayish-yellow (5Y 8/4) marl. The member is highly fossiliferous and contains very large Inoceramus shells, pelecypod imprints, plant fragments, and some ammonites. Eifler (1951) considered beds of similar composition in the Barrilla Mountains to be Austin in age. He identified the large Inoceramus tentatively as Inoceramus undulatoplicatus. A total thickness of 122 feet was measured in the north bank of Little Aguja Creek (Measured Section 7).

Upper marl member.- The upper member of the K90 formation is much better exposed and more extensive in outcrop. It is everywhere a dark yellowish-orange (10YR 6/6) calcareous clay (plastic when wet) containing abundant Exogyra ponderosa ?, Exogyra laeviscula, and Gryphaea wratheri. These fossils are characteristic of this member, especially near the top, and wherever the upper part of the K90 is exposed under Jeff conglomerate they will be found. Locally, gypsum is abundant. At Washington Tank (Measured Section 8) on the KC Ranch, 230 feet of the upper member of the K90 marl containing abundant gypsum crystals and Exogyra ponderosa is exposed; a 15-foot cross-bedded, coarse-grained sandstone is present in Unit 10, and a similar sandstone in upper K90 beds is exposed in the valley south of Cherry Canyon Ranch road. Discontinuous nodular septarian-bearing limestone beds occur in Unit 11, Measured Section 8, near Washington Tank.

Microscopic examination of samples from Washington Tank disclosed shell fragments, Inoceramus prisms, volcanic glass, fossilized wood, and limonite. Some samples were composed entirely of Inoceramus prisms.

Fossils and correlation.- No fossils were collected from the lower marl member of the K90 formation; therefore, an exact age cannot be given. Several individuals of Peroniceras sp., an ammonite of Senonian age, were collected from the K90m member. As Peroniceras is an Austin-chalk form in Central Texas, the writer considers the K90m member as the equivalent of the Austin chalk. Whether the lower marl member is Austin or Eagle Ford in age cannot be ascertained as yet.

Fossils collected from the K90m member by Wheeler and Brundrett include:

KIND		SOURCE	
	Collection No.	Unit	Measured Section
Ammonites:			
Peroniceras sp.	UT 10481, UT 10484, UT 10485	3	7
Texanites sp. ?	UT 10311	2	16
Proplacenticeras sp.	UT 10317	Near old dam on Madera Springs road.	
Glyptoxoceras sp. ?	UT 10316	Near old dam on Madera Springs road.	
Pelecypods:			
Inoceramus sp.	UT 10346	2	16
Gryphaea sp.	UT 10347, UT 10348	2	16

Fossils are much more abundant in the upper marl member of the K90 formation, and their identification is less ambiguous. Exogyra ponderosa and Gryphaea wratheri are common Austin-Taylor forms in Central Texas. Eifler (1951) reported Exogyra ponderosa and Gryphaea newberryi ? in his "Taylor" marl in the Barrilla Mountains. As Gryphaea newberryi is a Turonian form, the writer conjectures that this fossil has been incorrectly identified and may possibly be Gryphaea wratheri.

Taylor (1952) and Moyer (1952), working in the area to the north of the mapped area, identified similar beds containing *Exogyra ponderosa* as being of Taylor age.

The only ammonite collected from the upper marl member in Measured Section 8 came from Unit 3 and was identified as *Texanites* ? sp. This form has no small tubercles or nodes on the venter between the ribs. According to Keith Young (oral communication, 1954) species of *Texanites* without intercalated ribs are not known to occur higher than the Burditt marl at Austin, Texas. He considers this species of *Texanites* to be of Austin age.

The following fossils were collected by Wheeler and Brundrett from the upper marl member of the K90 formation:

KIND	Collection No.	SOURCE	
		Unit	Measured Section
Ammonites:			
Texanites spp.	UT 10303, UT 10305, UT 10314	Old dam on road to Madera Springs.	
Texanites ? sp.	UT 10304	3	8
Proplacenticeras sp.	UT 10317	Old dam.	
Glyptoxoceras sp. ?	UT 10306	7	8
Baculites sp.	UT 10302	Old dam.	
Engonoceras sp.	UT 10309	Old dam.	
Pelecypods:			
Exogyra ponderosa	UT 10350	6	8
Exogyra laeviscula	UT 10310, UT 10313	Base of Star Mountain. NE $\frac{1}{4}$ Sec. 5, Blk. 357.	

KIND	Collection No.	SOURCE Unit	Measured Section
Pelecypods--Continued:			
Exogyra sp. aff. E. laeviscula	UT 10354	On Big Aguja Creek east of Jim Duncan Ranch house.	
Gryphaea wratheri	UT 10355	On Big Aguja Creek east of Jim Duncan Ranch house.	
Gryphaea sp.	UT 10343	West of adobe house at Washington Tank.	
Durania sp.	UT 10490	Old dam on road to Madera Springs.	

The K90 beds are similar to beds in the Terlingua area studied by Udden (1907). He described the Terlingua formation as 1,280 feet of impure chalk and clay above the Boquillas formation. He collected Exogyra ponderosa from the clay above the chalk and considered it to be of Taylor age. In the chalky beds below the clay he found, moreover, large Inoceramus sp. and Inoceramus undulatoplicatus.

Until further collecting of fossils, especially ammonites, is done in this area, it seems impossible to accurately date the yellowish clay that is present directly beneath the Tertiary lava. Based on the fauna thus far collected, the writer is confident that it will turn out to be equivalent to the Taylor marl of Central Texas.

Samples of the microfauna of the upper marl member of the K90 formation collected at Washington Tank were examined by S. P. Ellison, who identified the following microfossils:

Foraminifers:

Globotruncana sp.

Gumbelina sp.

Anomalina taylorensis Carsey

Kyphopyxa christneri

Dorothea sp.

Palmula sp.

Ostracods

Ellison (oral communication, 1954) considered the marl to be of Taylor age. Very large *Palmula* sp. and *Anomalina taylorensis* are typical of the Taylor marl in Central Texas.

Deposition.- The upper Cretaceous sea steadily advanced landward over Trans-Pecos Texas receiving large amounts of mud and silt. During deposition of the K80 limestone and K90m limestone member, the mapped area was probably covered by a shallow, clear sea which covered a continental shelf. The marl members of the K90 formation were deposited in a shallow-water, near-shore environment; they probably represent the fine mud deposited near-shore in a regressive stage of the sea.

Summary.- It is apparent from the present study that the thickness of the K90 formation is much greater than has been hitherto reported by geologists (Head, 1948, p. 18; Zimmerman, 1950, p. 18).

Taylor (1952) measured only 200 feet of K90 marl in the vicinity of Gomez Peak, but he probably missed part of the section, for the usual outcrop is obscure and good contacts are rarely exposed. An outcrop of

K90 marl in the valley south of Cherry Canyon Road between a Buda outcrop and Tertiary lava covers a distance of three quarters of a mile: to assign it a dip of 10°, which is conservative, would indicate a much greater thickness than Taylor measured. There is no indication of the K90m chalky limestone member at this place.

The combined thickness of the members of the K90 formation in this area totals 650 feet. This is considered to be a conservative figure, since the contacts between individual units are not everywhere well exposed. Further evidence of a thick section of K90 marl is given by the Humble Oil and Refining Company well near Star Mountain. This well had 732 feet of upper Cretaceous beds; assuming a thickness of 300 feet for the Boquillas and K80 formations combined, this leaves at least 432 feet of K90 beds encountered in this well (Skinner, 1948, p. 61).

K100 FORMATION

K100 is a temporary field term applied to black, petroliferous limestone and shale exposed in widely scattered outcrops beneath Tertiary volcanic rocks along the Davis Mountain front.

Taylor (1952) first reported the presence of the black limestone near the base of Newman Peak. A small outcrop in landslide material west of Duncan Kingston house, 100 yards northwest of an aluminum gate, proved to be a hard, black limestone giving off a petroliferous odor on fresh surface. The only outcrop of any size occurs on the east bank of Little Aguja Creek 3 miles south of the J. C. Duncan Ranch house, 500 yards east of the road. There the K100 is a dark gray (N3) medium-bedded, petroliferous shale underlying Star Mountain rhyolite (Measured Section 9). This outcrop forms a steep cliff which is referred to by the ranchers as the Black Cliffs. A total thickness of 210 feet was measured in a draw south of the outcrop.

The only fossils collected from the K100 formation are <u>Inoceramus</u> sp. and <u>Gryphaea</u> sp.

The absence of the K100 formation over much of this area may be the result of erosion following uplift and prior to the extrusion of the lavas.

E C O N O M I C   G E O L O G Y

OIL AND GAS

No oil or gas has been discovered in the area covered by this report, nor has any test well been drilled. Petroleum from Cretaceous rocks would be shallow production, since the most likely reservoir rock is the Cox sandstone which lies beneath the *Kent Station limestone at a depth of from 500 to 1,500 feet. Structural conditions for the accumulation of hydrocarbons in this area are good, for it lies astride the Kingston-Neal anticline (Head, 1948), and is in a region where the Permian-Cretaceous unconformity is well developed.

The absence of source beds in the close proximity of the possible reservoir rocks subtracts somewhat from the potentialities of this area, but the writer believes that this factor alone is not sufficient to condemn it.

The maximum structural uplift seems to be just south of Cherry Draw on the Duncan Kingston Ranch, and the writer suggests that this area has some possibilities and warrants a test well. Older and deep-seated rocks probably offer more possibilities for production of hydrocarbons than does the Cretaceous.

BUILDING STONE

The only rock used for building stone is taken from the limestone flags of the K71 member of the Boquillas formation. Many of the ranch buildings in the mapped area have been constructed of this stone. Stone from a quarry on the Duncan Kingston Ranch was used to build the old Kingston home on Madera Draw. One home, up in the mountains, has been constructed of T40 rhyolite (Wheeler, 1955).

GROUND WATER

In the mapped area water is of prime importance for stock and irrigation. The ranchers depend on drilled wells supplemented by springs in the mountains. These springs, which are very small, are most active during periods of heavy rainfall, and are dry during much of the year. Drilled wells encounter abundant water in the gravel beneath the valley floor in the Rounsaville syncline. In the area of outcropping limestone the only water obtainable in sufficient quantities is derived from the Cox sandstone, where it is in reach of the drill. Small wells occasionally are completed in limestone, but their output does not warrant their drilling.

Water used for irrigation east of the area in the vicinity of Balmorhea is obtained from several large springs. San Salamar Spring at Toyahvale flows 33 million gallons a day, and Phantom Lake Spring flows approximately 8 million gallons a day. The flow of Phantom Lake Spring is augmented by local rains in the Davis Mountains, whereas San Salamar Spring actually flows more in dry season than it does in the wet season. Deep wells to the east do not affect the flow of these springs.

AGRICULTURE

The principal occupation is ranching. Sheep, goats, and cattle are raised in large numbers on the ranches at the foot of the mountains, while cotton and grain are grown on irrigated lands near Balmorhea. A few small fields south and east of the mapped area are cultivated in tillable soil developed on the Boquillas and K90 formations. Older Cretaceous limestones, the Buda and the *Kent Station, support a sparse covering of small shrubs on which goats and sheep graze; very little grass grows on the exposed limestones, and the type of animal grazing in an area is a clue to the bedrock present. The sheep and goats will be found grazing on limestone outcrops, while cattle stay well down on the alluvium-covered flats.

R E F E R E N C E S

Adkins, W. S. (1920) The Weno and Paw Paw Formations of the Texas Comanchean; University of Texas Bulletin No. 1856.

__________ (1928) Handbook of Texas Cretaceous Fossils; University of Texas Bulletin No. 2838.

__________ (1932) Some Upper Cretaceous Ammonites in Western Texas; University of Texas Bulletin No. 3101.

__________ (1933) The Mesozoic Systems in Texas; University of Texas Bulletin No. 3232.

Baker, C. L. (1927) Exploratory Geology of a Part of Southwestern Trans-Pecos Texas; University of Texas Bulletin No. 2745.

__________ and Bowman, W. F. (1918) Geologic Exploration of Southeastern Front Range of Trans-Pecos Texas; University of Texas Bulletin No. 1753.

Baker, G. B. (1952) Structure of the Northeastern Chispa Quadrangle, Culberson and Jeff Davis Counties; Unpublished M. A. Thesis, University of Texas.

Bose, E. (1920) On a New Ammonite Fauna of the Lower Turonian of Mexico; University of Texas Bulletin No. 1856.

__________ and Cavins, O. A. (1928) The Cretaceous and Tertiary of Southern Texas and Northern Mexico; University of Texas Bulletin No. 2748.

Cobban, W. A. (1952) Cenomanian Ammonite Fauna from the Mosby Sandstone of Central Montana; U. S. Geological Survey Professional Paper 243-D.

Cragin, F. W. (1893) A Contribution to the Invertebrate Paleontology of the Texas Cretaceous; Texas Geological Survey, 4th Annual Report, pt. 2; pp. 139-294 il.

DeFord, R. K. (1951) Trans-Pecos Province, West Texas and Southeast New Mexico; Amer. Assoc. Petr. Geol. Bull., Vol. 35, No. 2; pp. 347-352.

__________ (1946) Grain Size in Carbonate Rocks; Amer. Assoc. Petr. Geol. Bull., Vol. 30; pp. 1921-1928.

D'Orbigny, A. (1840) Les Animaux Mollusques et Rayonnes; Fossils de France, Chez L'Auteur, Reu Louis-Le-Grande No. 5, Paris.

Feray, D. E., et al (1949) Cretaceous of Austin, Texas, Area; Guidebook, 17th Annual Field Trip, Shreveport Geological Society.

Goddard, E. N., Trask, P. D., DeFord, R. K., and Rove, O. N. (1948) Rock-Color Chart; National Research Council, Washington, D. C.

Grossouvre, A. D. (1894) Les Ammonites de la Craie Superieure; Ministere Des Travaux Publics, Imprimerie Nationale, Paris.

Haas, O. (1946) Intra-specific Variation In, and Ontogeny of, Prionotropis Woolgari and Prionocyclus Wyomingensis; American Museum of Natural History Bulletin, Vol. 86, Article 4, New York.

Holt, C. L., Jr. (1949) Geology of Kent Station Area Culberson and Jeff Davis Counties, Texas; Unpublished M. A. Thesis, University of Texas.

Jones, C. T. (1938) Cretaceous and Eocene Stratigraphy of Barrilla and Eastern Davis Mountains of Trans-Pecos Texas; Amer. Assoc. Petr. Geol. Bull., Vol. 22, No. 10; pp. 1423-1439.

Kossmat, Franz (1895) Untersuchungen Uber Die Sudindische Kreide-Formation; Alfred Holder, Wien.

Lozo, F. E. and Perkins, B. F. (1951) The Woodbine and Adjacent Strata of the Waco Area of Central Texas; A Symposium, Fondren Science Series No. 4; Southern Methodist University Press.

Moreman, W. L. (1927) Fossil Zones of the Eagle Ford of North Texas; Journal of Paleontology, Vol. 1, No. 1; pp. 89-101. 1 fig.; 4 plates.

__________ (1942) Paleontology of the Eagle Ford Group of North and Central Texas; Journal of Paleontology, Vol. 16, No. 2; pp. 192-220; 4 plates, 2 fig.

Moyer, G. L. (1952) Cretaceous Geology of the San Martine Quadrangle, Reeves and Culberson Counties, Texas; Unpublished M. A. Thesis, University of Texas.

Payne, T. G. (1942) Stratigraphical Analysis and Environmental Reconstruction; Amer. Assoc. Petr. Geol. Bull., Vol. 26, No. 11; pp. 1697-1770.

Prather, J. K. (1902) On the Fossils of the Texas Cretaceous, Especially Those Collected at Austin and Waco; Texas Academy of Science Transactions, Vol. 4; pp. 85-87.

Price, W. A. (1925) Caliche and Psuedo-Anticlines; Amer. Assoc. Petr. Geol. Bull., Vol. 9, No. 6; pp. 1009-1017.

Schluter, C. (1871-1876) Cephalopoden Der Oberen Deutschen Kreide.

Sellards, E. L. and Baker, C. L. (1934) The Geology of Texas; University of Texas Bulletin No. 3401; p. 137.

Skinner, J. W. (1948) Road Log, Limpia Canyon-Barrilla Mountains Field Trip; West Texas Geological Society, p. 61.

Stanton, T. W. (1947) Studies of Some Comanche Pelecypods and Gastropods; U. S. Geological Survey Professional Paper 211.

Stephenson, L. W. (1922) Some Upper Cretaceous Shells of the Rudistid Group from Tamaulipas, Mexico; Proceedings of the U. S. National Museum; Vol. 61, Art. 1; pp. 1-28; Government Printing Office, Washington, D. C.

__________ and Reeside, J. B., Jr. (1938) Comparison of Upper Cretaceous Deposits of Gulf Region and Western Interior Region; Amer. Assoc. Petr. Geol. Bull., Vol. 22, No. 12; pp. 1629-1638.

Taylor, D. R. (1952) Stratigraphy of the Gomez Peak Area, Trans-Pecos Texas; Unpublished M. A. Thesis, University of Texas.

Udden, J. A. (1907) A Sketch of the Geology of the Chisos Country, Brewster County, Texas; University of Texas Bulletin No. 93; pp. 21-41.

__________, Baker, C. L. and Bose, E. (1916) Review of the Geology of Texas; University of Texas Bulletin No. 44; pp. 12-16, 63.

von Steeruwitz, W. H. (1892) Trans-Pecos Texas; Texas Geological Survey, 4th Annual Report.

Warren, P. S. (1930) Descriptions of New Species of Fossils from Parts of Pease River and Grande Prairie Districts, Alberta; From Report No. 21, Research Council of Alberta.

__________ (1930) Three New Ammonites from the Cretaceous of Alberta; From the Transactions of the Royal Society of Canada, Third Series, Vol. XXIV, Section IV.

Wheeler, J. O. (1955) <u>Geology of the Northeastern Front of the Davis Mountains</u>; Unpublished M. A. Thesis, University of Texas.

Zimmerman, J. B. (1950) <u>Jeff Conglomerate Northeastern Davis Mountains, Texas</u>; Unpublished M. A. Thesis, University of Texas.

Plate III. Silicified fossils from the K71 limestone member of the Boquillas formation.

Fig. 1, 7. Forbesiceras sp. "B" n.sp., x 1, UT 10737. Locality: Duncan Kingston Ranch, south of Cherry Draw. Horizon: Basal K71.

Fig. 2-3. Forbesiceras sp. "A" n.sp., x 1, UT 10734. Locality: Duncan Kingston Ranch, south of Cherry Draw. Horizon: Basal K71.

Fig. 4. Turrilites sp. aff. T. tuberculatus, x 1, UT 10285. Locality: Duncan Kingston Ranch, south of Cherry Draw. Horizon: Basal K71.

Fig. 5. Forbesiceras sp. (juvenile), x 2, UT 10739. Locality: Duncan Kingston Ranch, south of Cherry Draw. Horizon: Basal K71.

Fig. 6, 10. Metoicoceras irwini Moreman, x 1, UT 10257. Locality: Unit 1, Measured Section 5, at Dry Tank. Horizon: Upper K71. (Not silicified).

Fig. 8-9. Forbesiceras sp. "A" n.sp., x 1, UT 10282. Locality: Duncan Kingston Ranch, south of Cherry Draw. Horizon: Basal K71.

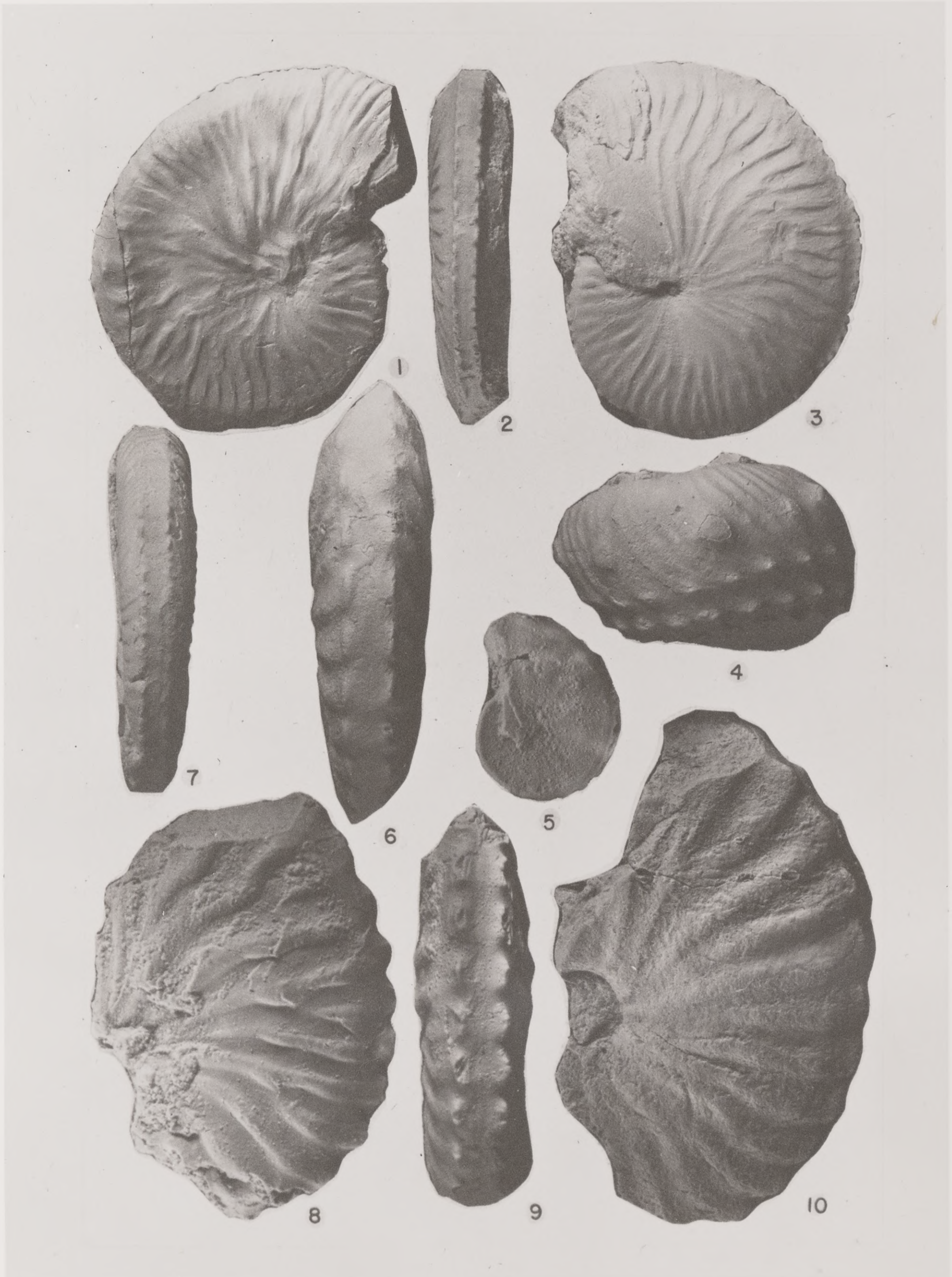

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Plate IV. Silicified fossils from the K71 limestone member of the Boquillas formation.

Fig. 1-2. Phylloceras sp., x 2, UT 10330. Locality: Duncan Kingston Ranch, south of Cherry Draw. Horizon: Basal K71.

Fig. 3-4. Phylloceras sp., x 2, UT 10743. Locality: Duncan Kingston Ranch, south of Cherry Draw. Horizon: Basal K71.

Fig. 5-6. Phylloceras sp., x 2, UT 10742. Locality: Duncan Kingston Ranch, south of Cherry Draw. Horizon: Basal K71.

Fig. 7-8. Phylloceras sp., x 2, UT 10740. Locality: Duncan Kingston Ranch, south of Cherry Draw. Horizon: Basal K71.

Fig. 9-10. Phylloceras sp., x 2, UT 10741. Locality: Duncan Kingston Ranch, south of Cherry Draw. Horizon: Basal K71.

Fig. 11. Turrilites sp. aff. T. bergeri, x 2, UT 10290. Locality: Duncan Kingston Ranch, south of Cherry Draw. Horizon: Basal K71.

Fig. 12. Turrilites sp. "A" n.sp., x 1, UT 10738. Locality: Duncan Kingston Ranch, south of Cherry Draw. Horizon: Basal K71.

Fig. 13. Turrilites sp. "A" n.sp., x 1, UT 10284. Locality: Duncan Kingston Ranch, south of Cherry Draw. Horizon: Basal K71.


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MEASURED SECTIONS

Descriptive sections of rock units were made in the field by Wheeler and the writer during the summer of 1953. Sections are numbered consecutively from 1 through 17 and are so indicated on the map (Pl. II). Not all sections are included in this paper; for sections of the Tertiary formations the reader is referred to Wheeler (1955). Measured Sections 10, 11, and 12 are omitted from this paper.

Measured Section 1

Nodular member of the *Kent Station limestone. Beginning 5 feet above base of the Buda limestone and ending 3.8 feet below top of fossiliferous member of *Kent Station limestone. Just south of road at steep cliff on Nelson Lethco Ranch, 3.1 miles west along Lethco Ranch road from U. S. Highway 290. SE$\frac{1}{4}$SE$\frac{1}{4}$ Sec. 47, Blk. C13, PSL Survey (Pl. II). (See Road Log 1).

Unit		Thickness Feet
17	Limestone, hard, reefy, slabby; fresh surface flashing and white (N8); weathering into large flaggy slabs which ring when struck with hammer; basal part of Buda limestone.......................	5
	BUDA-*KENT STATION CONTACT	
16	Limestone, hard, irregularly bedded, medium-bedded; fresh surface very light gray (N8); flashing surfaces. Containing <u>Trigonia</u> sp., echinoids, gastropods and pelecypods (K50 lentil of Taylor). <u>Tylostoma</u> sp., <u>Pecten</u> sp., <u>Heteraster</u> sp............	12
15	Limestone, hard, thick-bedded, irregularly bedded; fresh surface, yellowish-gray (5Y 7/2) and grayish-orange (10YR 5/7) on weathered surface. Fresh surface flecked with limonite. Ledge-forming.......	5

Unit		Thickness Feet
14	Limestone, hard, nodular and irregularly bedded; fresh surface, very light gray (N8) and having flashing surfaces. Contains pelecypods and gastropods in cross section........................	36
13	Limestone, hard, thick-bedded, flashing surfaces, pepper-speckled, limonitic; fresh surface yellowish-orange (10YR 6/6), weathered surface slightly pitted...	4.5
12	Same as Unit 8. _Tylostoma_ sp., _Pecten_ (_Neithea_) _texanus_ (Roemer).................................	18
11	Limestone, hard, thick-bedded; fresh surface gray yellowish-orange (10YR 7/4) to yellowish-gray (5Y 7/2). Weathers to a moderate yellowish-brown (10YR 5/4). Contains _Pecten_ sp., clam borings; also pelecypods, and gastropods in cross section....	9
10	Same as Unit 8...	13
9	Limestone, hard, nodular, irregularly bedded, medium- to thick-bedded; fresh surface yellowish-gray (5Y 7/2); pale yellowish-brown on weathered surface (10YR 6/2). Contains many pelecypods and gastropods exposed in cross section. Largely covered by colluvium which may hide marly and thin beds........	7
8	Limestone, hard, irregularly and unevenly bedded, nodular, containing ledges of medium-bedded limestone. Yellowish-gray (5Y 7/2) on fresh surface and medium yellowish-orange (10YR 7/6) on weathered surface; fossiliferous, limonite freckled. Slope formed largely covered by colluvium................	37
7	Limestone, hard, nodular, medium-bedded, flashing calcite surfaces and flecked with limonite in places; fresh surface grayish-orange (10YR 7/4), pepper-speckled in places, weathers to a dark yellowish-orange (10YR 6/6). Contains _Gryphaea_ sp. The top of this unit forms a yellowish-orange ledge which may be traced (2.0 feet thick).........	9

Unit		Thickness Feet
6	Limestone, hard, nodular, containing interbeds of marl, color same as Unit 5. Slope is largely covered with debris. (Echinoids ? in float)........	7
5	Limestone, hard, thin- to medium-bedded, sparsely fossiliferous; fresh surface pale yellowish-orange (10YR 8/6) to grayish-orange (10YR 7/4), weathered surface moderate yellowish-brown (10YR 5/4) to dark yellowish-orange (10YR 6/6).........................	2.5
4	Limestone, hard, nodular; containing thin, irregular, marly beds. Similar to Unit 2. Forms slight topographic bench on the slope. Large gastropods (<u>Tylostoma</u> sp.)...................................	13
3	Limestone, massive, nodular, very pale orange (10YR 8/2), containing abundant <u>Gryphaea</u> sp., <u>Engonoceras</u> sp. Weathers to dark yellowish-orange (10YR 6/6). Forms heavy massive cliff above stream...	19
2	Limestone, hard, irregularly bedded, nodular, fresh surface very pale orange (10YR 8/2); nodules interbedded with thin, irregular, undulating 0.1 foot to 0.6 foot lenses of pale yellowish-orange (10YR 8/6) marl. Lower 4 feet contain abundant <u>Gryphaea</u> sp.; <u>Holectypus planatus</u> (Roemer), <u>Turritella</u> sp., <u>Heteraster</u> sp. ?, <u>Tetragramma</u> sp., <u>Pecten</u> sp., <u>Nerinea</u> sp., pelecypods..............................	12

BASE OF NODULAR MEMBER, TOP OF FOSSILIFEROUS MEMBER OF *KENT STATION LIMESTONE

1	Limestone, hard, medium and unevenly bedded, very pale orange (10YR 8/2) to grayish-orange (10YR 7/4) on fresh surface, uneven fracture and containing small calcite crystals, very fossiliferous, containing <u>Gryphaea</u> sp. and <u>Mortoniceras</u> sp. Interbedded with limestone are thin, indurated, lenticular, slickensided marl partings 0.2 foot to 0.3 foot thick with color same as above. <u>Cymatoceras</u> sp., <u>Enallaster</u> sp., <u>Turritella</u> sp., <u>Cyprimeria</u> sp., <u>Tetragramma</u> sp., <u>Holectypus</u>	

Unit		Thickness Feet
	planatus (Roemer), Pervinquieria (Leonites) maxima (Lasswitz), gastropods, clams..........................	3.8

Total thickness of nodular member	204 feet
Exposed thickness of fossiliferous member	4 feet
Exposed thickness of *Kent Station limestone	208 feet
Exposed thickness of Buda limestone	5 feet
Total thickness of Measured Section 1	213 feet

Measured Section 2

Buda limestone. Beginning 10 feet above the base of the Boquillas formation and ending 22 feet below the top of the nodular member of the *Kent Station limestone. Location: North bank of Cherry Draw, north of Cherry Canyon Road. East of windmill on Cherry Draw and 3.1 miles from U. S. Highway 290. SW¼NE¼ Sec. 29, Blk. 57, T. 9, T & P RR Co. Survey (Pl. II). (See Road Log 3).

Unit		Thickness Feet
22	Limestone, thin-bedded, flaggy, dense, calcite flashing surfaces, grayish-orange (10YR 7/4) to pale yellowish-orange (10YR 8/6), banded, sandy; flags are 0.2 foot to 0.5 foot in thickness and interbedded with thin, wavy marl layers of the same color as flags--mostly covered except flaggy layers..	10
	BASE OF BOQUILLAS FORMATION, TOP OF BUDA LIMESTONE	
21	Limestone, hard, dense, thin- to medium-bedded, flashing calcite surfaces, fossiliferous, very pale orange (10YR 8/2). <u>Nerinea</u> <u>volana</u> (Cragin), colonial corals, scattered chert..........................	7
20	Limestone, massive, hard, dense, flashing calcite surfaces, yellowish-gray (5Y 7/2). <u>Gryphaea</u> bed....	1.0
19	Limestone, hard, dense, medium-bedded, grayish-orange (10YR 7/4) to very pale orange (10YR 8/2)....	1.0
18	Limestone, hard, dense, thin-bedded, flashing calcite surfaces, very pale orange (10YR 8/2), very fossiliferous, weathers to form flaggy surface; flags are smaller than those of flaggy Unit 16; mostly covered, <u>Nerinea</u> <u>volana</u> (Cragin), gastropods, pelecypods, silicified corals, contains numerous <u>Gryphaea</u> beds..	8
17	Limestone, hard, dense, medium-bedded, pinpoint flashing surfaces, yellowish-gray (5Y 7/2), contains numerous bore holes................................	1.5
16	Limestone, reefy, hard, dense, calcite flashing surfaces, flaggy, thin-bedded to thick-bedded,	

Unit		Thickness Feet
	unevenly, irregularly bedded, pale greenish-yellow (10Y 8/2) to very pale orange (10YR 8/2); forms flaggy surface, contains small and scattered amounts of chert; <u>Pecten</u> <u>roemeri</u> Hill, <u>Nerinea</u> <u>volana</u> (Cragin)..	26
15	Limestone, similar to Unit 13. <u>Pecten</u> <u>roemeri</u> Hill.	15
14	Limestone, hard, dense, evenly bedded, medium-bedded, reefy to fossiliferous, calcite flashing surfaces, yellowish-gray (5Y 7/2), speckled with limonite..	2.0
13	Limestone, hard, dense, massive, fossiliferous, very pale orange (10YR 8/2). Weathers to form surface covered with numerous small and irregular blocks....	18
12	Limestone, massive, reefy, dense, flashing calcite surfaces, fossiliferous, yellowish-gray (5Y 7/2), forms slope covered with flaggy limestone fragments.	24
11	Limestone, hard, dense, medium- to thin-bedded, calcite flashing surfaces, yellowish-gray (5Y 7/2), interbedded with hard, nodular limestone; sandy at base and lowest bed contains black chert pebbles; ammonites and <u>Ostrea</u> sp...........................	4.5
	BASE OF UPPER MEMBER, TOP OF KC SANDSTONE MEMBER	
10	Sandstone, hard, thin-bedded to medium-bedded, calcareous, limonitic, fine-grained, pepper-speckled, slightly glauconitic, fossiliferous, dark yellowish-orange (10YR 6/6).......................	3.5
9	Sandstone, soft to hard, laminated, wavily bedded, limonitic, calcareous, fine- to medium-grained, fossiliferous, glauconitic, contains bore holes and black chert pebbles...........................	0.8
	BASE OF KC SANDSTONE MEMBER, TOP OF LOWER MEMBER	
8	Limestone, hard, medium- to thick-bedded, massive, dense, reefy, pinpoint flashing calcite surfaces,	

Unit		Thickness Feet
	very pale orange (10YR 8/2), much iron stain at base; contact wavy to irregular; Budaiceras sp......	6
	BASE OF BUDA LIMESTONE, TOP OF *KENT STATION LIMESTONE	
7	Limestone, medium hard, unevenly bedded, nodular, pinpoint flashing calcite surfaces, light gray (N7) to pale yellowish-orange (10YR 8/6), stained with secondary limonite, very nodular at base, top less nodular and contains many bore holes; Turrilites brazoensis Roemer and Cymatoceras sp. 2.5 feet from top; Pecten sp.; Echinoids in float...........	4.1
6	Limestone, hard, dense, medium-bedded, irregularly bedded, light gray (N7); weathers to a pale yellowish-orange (10YR 8/6). Gryphaea bed, Neithea sp..	2.5
5	Limestone, hard, dense, medium- to thick-bedded, evenly bedded, pinpoint flashing calcite surfaces, yellowish-gray (5Y 7/2)............................	2.5
4	Limestone, hard, thin-bedded, irregularly bedded, lenticular, wavy, nodular, yellowish-gray (5Y 7/2), pinpoint flashing calcite surfaces, speckled with limonite, irregular and undulating surface, top and bottom..	0.9
3	Same as Unit 2, but with undulating surface, top and bottom..	3.7
2	Limestone, hard, dense, evenly bedded, thick-bedded, pinpoint flashing calcite surfaces, light gray (N7) to grayish-orange (10YR 7/4), containing an extreme abundance of bore holes; top surface highly irregular, showing undulations up to 6 inches deep. Bore holes occur in upper surface..................	3.0
1	Limestone, hard, dense, evenly bedded, thin- to medium-bedded, pinpoint flashing calcite surfaces, yellowish-gray (5Y 7/2), containing an occasional bore hole..	2.3

Total thickness of upper member of Buda limestone	108	feet
Total thickness of KC sandstone member	5	feet
Total thickness of lower member of Buda limestone	6	feet
Total thickness of Buda limestone	119	feet
Exposed thickness of Boquillas formation	10	feet
Exposed thickness of *Kent Station limestone	19	feet
Total thickness of Measured Section 2	148	feet

Measured Section 3

Buda limestone beginning top of hill and ending at base of hill at stream level. Location: On south side of Rattlesnake Draw approximately half a mile updraw from mouth. SW$\frac{1}{4}$NW$\frac{1}{4}$ Sec. 7, Blk. 57, T. 9, T & P RR Co. Survey (Pl. II). (See Road Log 2). Going down dip (E) towards the Boquillas formation outcrop there is more of Unit 6 than 5 feet, and overlying it are beds containing much nodular chert. The dip of the beds near the contact increases from 9^{o} to 15^{o} in the space of 220 feet. The slope of the hill is $1\frac{1}{2}^{o}$. Using 9^{o} dip over a distance of 220 feet an additional 24 feet of section was computed.

Unit		Thickness Feet
6	Limestone, hard, dense, medium- to thick-bedded, many small flashing surfaces. Fresh surface yellowish-gray (5Y 7/2), weathered surface very pale orange (10YR 8/2) to grayish-orange (10YR 7/4). On the weathered slope there are many blocky pieces up to 4 inches by 6 inches. The upper portion of Unit 6 contains the more massive beds. Unit 6 is the cap rock of the hill..........................	5
5	Limestone, flaggy, thin- to medium-bedded, hard, dense, many pinpoint flashing surfaces, fresh surface grayish yellowish-orange (10YR 7/4), weathered surface pale yellowish-brown (10YR 6/2), and pitted in places. Sparingly fossiliferous, some beds reefy and/or oolitic. Slope covered with flags..	17
4	Limestone, hard, dense, unevenly bedded, nodular in places, thin- to medium-bedded, fresh surface grayish-yellow (5Y 7/2) containing platy calcite and fresh flecks of limonite; weathered surface light olive gray (5Y 6/1). Fresh surface contains. many pinpoint flashing surfaces. The slope formed by Unit 4 is covered with much nodular material.....	17
3	Limestone, hard, sandy, medium- to thick-bedded, evenly bedded, large flashing surfaces of calcite; fresh surface very light gray (N8), weathered surface grayish-orange (10YR 7/4), and solution pitted. Sand is fine-grained, quartz, limonitic; disseminated sparingly and in small lenses	

Unit		Thickness Feet
	throughout. Fragments from a hammer blow are sharp and angular. Beds vary in sand content........	5
2	Sandstone, indurated, thin-bedded, lenticular, moderate olive brown (10YR 4/4) on fresh surface to moderate brown (10YR 5/4) on weathered surface, fine-grained, angular to subangular, quartz, glauconitic, limonitic, calcareous. Contains pelecypods..	4.3
1	Limestone, hard, dense, reefy, cherty, thick-bedded to massive, grayish-orange pink (5Y 7/2) on fresh surface. Forms ledge at base of section. Base not exposed. Weathers to a yellowish-brown with large cherty areas present; fossiliferous, massive ledge of basal Buda..	3.7

Total thickness of Buda limestone measured 52 feet

Additional thickness of Buda limestone computed 24 feet

Total thickness of Buda limestone 76 feet

Measured Section 4

K80 limestone and K75 marl member of Boquillas formation, beginning at the base of the K90 marl and ending 15 feet below the top of the K71 limestone member. Section measured in draw at base of Gozar terrace, on south side of Dry Tank on KC Ranch, south of corrals near main KC road. $NW\frac{1}{4}NW\frac{1}{4}$ Sec. 29, Blk. 57, T. 9, T & P RR Co. Survey (Pl. II). (See Road Log 2). Strike N 29° W. Dip 6° - 16° SW. No good contact with overlying K90 marl obtainable at this locality.

Unit		Thickness Feet
	BASE OF K90 MARL, TOP OF K80 LIMESTONE	
16	Same as Unit 15, but limestone layers are harder and top beds contain animal borings....................	30
15	Limestone, thin-bedded, evenly bedded, soft, chalky, yellowish-gray (5Y 8/1) to white (N9), fossiliferous, crumbly, interbedded with laminated, flaky, evenly bedded marl layers. Weathered surface forms series of small hogbacks due to resistant limestone layers and alternating nonresistant marl layers. No fresh marl exposed on account of deep weathering. Marl layers from 2 to 4 feet thick. <u>Prionocyclus</u> spp....	36
14	Limestone, thin-bedded, evenly bedded, soft, nodular, chalky, impure, yellowish-gray (5Y 7/2), interbedded with paper thin, laminated, evenly bedded, friable marl. <u>Prionocyclus</u> spp., <u>Inoceramus</u> <u>labiatus</u> (Schlotheim)..	13
	BASE OF K80 LIMESTONE, TOP OF BOQUILLAS FORMATION	
13	Limestone, thin-bedded, evenly bedded, hard, dense, pinpoint flashing surfaces, flaggy, limonitic, pale yellowish-brown (10YR 6/2), interbedded with friable marl. Limestone beds average 0.3 foot in thickness. Fresh marl not exposed on account of deep weathering. Weathered surface covered with flags. <u>Inoceramus</u> <u>labiatus</u> (Schlotheim)..................	26
12	Marl, friable, dark yellowish-orange (10YR 6/6) with interbedded thin limestone layers. Similar to Unit 11, but limestone layers are fewer and thinner. Ammonites occur in limestone layers.	

Unit		Thickness Feet
	Coilopoceras n.sp. "hazzardi" Adkins, Coilopoceras cf. austinense Adkins, Coilopoceras sp., Prionocyclus sp., Coilopoceras n.sp. aff. C. "hazzardi" Adkins nomen nudum, unidentified fish......................	48
11	Marl, friable, dark yellowish-orange (10YR 6/6) to pale yellowish-orange (10YR 8/6), interbedded with thin, impure, chalky, evenly bedded, limonitic limestone layers. Limestone beds 0.5 foot to 0.3 foot thick and weather to form a semi-nodular hog-back. Marl layers are 2.0 feet to 3.0 feet thick and readily break down to form gentle slopes. Ammonites are exceedingly abundant in limestone layers. Coilopoceras sp., Coilopoceras springeri (Hyatt), Coilopoceras cf. austinense Adkins, Coilopoceras n.sp., Coilopoceras n.sp. "hazzardi" Adkins, Durania sp. Units 11 and 12 equivalent to Units 7 through 11, Measured Section 5.............	16
10	Marl, laminated, friable to indurated, yellowish-gray (5Y 7/2) to grayish-yellow (5Y 8/4). Collignoniceras eaglensis Adkins, Collignoniceras n.sp. aff. C. eaglensis Adkins, Coilopoceras cf. austinense Adkins, Inoceramus labiatus (Schlotheim)..	12
9	Limestone, indurated, evenly bedded, nodular, impure, slightly chalky, nonfossiliferous..........	0.5
8	Marl, laminated, friable to indurated, yellowish-gray (5Y 7/2) to grayish-yellow (5Y 8/4). Collignoniceras eaglensis Adkins, Collignoniceras n.sp. aff. C. eaglensis Adkins, Coilopoceras cf. austinense Adkins, Inoceramus labiatus (Schlotheim)..	11
7	Covered, probably largely marl....................	4
6	Shale, very thin-bedded to laminated, silty, calcareous, paper shale like; pale yellowish-orange (10YR 8/6) to dark yellowish-orange (10YR 6/6). These beds are evenly bedded, laminated, and show a banded appearance and weather into small flakes. Beds are paper-thin and form a surface covered with	

Unit		Thickness Feet
	small flakes 0.1 foot by 0.3 foot square and 1 mm. in thickness. Top of west side of second gully west of fence. Inoceramus labiatus ? (Schlotheim), Durania sp. Dip 12°. Equivalent to Unit 5, Measured Section 5....................................	6
5	Marl, interbedded with impure limestone. Same as Unit 4, but more marly. Fagesia pervinquieri (Bose), Inoceramus labiatus (Schlotheim). Dip 10°..	32
	BASE OF K75 MARL MEMBER, TOP OF K71 FLAGGY LIMESTONE MEMBER	
4	Limestone, hard, flaggy, very thin-bedded, evenly bedded, pale yellowish-orange (10YR 8/6), manganiferous, limonitic, interbedded with grayish-yellow (5Y 8/4) marl. More flaggy near base, becoming more marly at the top. Inoceramus sp., Inoceramus labiatus (Schlotheim). Dip 8°......................	10
3	Marl, soft to friable, laminated, very pale orange (10YR 8/2) to dark yellowish-orange (10YR 6/6), containing a thin, impure limestone (manganiferous) layer in the middle. Metoicoceras whitei..........	2.8
2	Limestone, impure, thin-bedded, irregularly bedded, nodular, exposed surface hummocky, pale yellowish-orange (10YR 8/6). Metoicoceras sp. aff. M. swallovi, Metoicoceras irwini Moreman, Acanthoceras sp., Calycoceras sp..................................	0.7
1	Marl, friable to soft, very thin-bedded to laminated, evenly bedded, dark yellowish-orange (10YR 6/6) to pale yellowish-orange (10YR 8/6), interbedded with indurated, very fine-grained, pepper-speckled, limonitic, sandy to silty limestone interbeds showing manganese stains and flashing calcite surfaces. Thickness of limestone interbeds ranges from ¼ inch to 1.5 inches. Calycoceras spp., Metoicoceras sp., Acanthoceras sp. aff. A. pentagonum (Brown & Hill), Metoicoceras sp. aff. M. whitei. Dip 6°. Exposed section..	2

Total thickness of K75 marl member	155	feet
Exposed thickness of K71 flaggy limestone member	16	feet
Exposed thickness of Boquillas formation	171	feet
Total thickness of K80 limestone	79	feet
Total thickness of Measured Section 4	250	feet

Measured Section 5

K75 marl member of Boquillas formation. Location: On west end of eastern Ninemile terrace on KC Ranch; southeast of ranch house. SE$\frac{1}{4}$NW$\frac{1}{4}$ Sec. 30, Blk. 57, T. 9, T & P RR Co. Survey (Pl. II). (See Road Log 2). The K75 typically shows up from a distance as a pale yellowish-orange (10YR 8/6) to dark yellowish-orange (10YR 6/6). Strike due N. Dip 5° east.

Unit		Thickness Feet
13	Limestone, hard, dense to chalky, slightly nodular, thin-bedded, largely covered........................	10
	BASE OF K80 LIMESTONE, TOP OF BOQUILLAS FORMATION	
12	Marl, same as below, interbedded with flaggy limestone similar to Unit 11. These flags have the tendency of developing a caliche coating. The unit becomes more flaggy as the top is approached. Limestone of this unit is hard, dense, flashing surfaces, light olive gray (5Y 6/1) on fresh surface to dark yellowish-orange (10YR 6/6) on weathered surface. Flags 0.1 foot to 0.3 foot. Largely covered. Equivalent to Unit 13, Measured Section 4...........	28
11	Limestone, hard, dense, evenly bedded, thin-bedded, flashing surfaces, flaggy; weathered surface pale yellowish-orange (10YR 8/6), fresh surface light olive gray (5Y 6/1). Slabs found on slope.........	0.5
10	Marl, friable, shaley weathering, indistinctly bedded, massive, very pale orange (10YR 8/2) to dark yellowish-orange (10YR 6/6). Largely covered with limestone fragments and marl wash from above. Forms steep slope. Containing large numbers of ammonites, secondary gypsum. Has 0.2 foot layer of dark yellowish-orange (10YR 6/6) indurated to friable marl at base. Turtle found in upper part...	39
9	Limestone, chalky..................................	0.8
8	Marl, non-laminated, in places forming nodules, blocky, evenly bedded, very pale orange (10YR 8/2) to pale yellowish-orange (10YR 8/6) containing limestone, nodular, evenly bedded, thin-bedded,	

Unit		Thickness Feet
	weathering into blocks. Richly fossiliferous in ammonites (color same as marl).....................	18
7	Limestone, nodular, similar to lower layers of nodular. Units 7 through 11 equivalent to Units 11 and 12, Measured Section 4.........................	0.3
6	Marl and siltstone, similar to Unit 5, but lacking flags...	18
5	Marl and siltstone, same as below but more silty. Contains few thin limestone flags (non-laminated). Marl and siltstone weather to form a surface of many small flakes or chips due to siltstone layers. Equivalent to Unit 6, Measured Section 4...........	6
4	Marl, same as in Unit 1, interbedded with limestone, medium to hard, evenly bedded, thin-bedded, semi-nodular, non-laminated; beds are 0.1 foot to 0.3 foot in thickness. Very pale orange (10YR 8/2) containing sandstone stringers 3.1 feet above base. Sandstone is fine-grained, light brown (5YR 6/4), evenly bedded, flaggy, thin-bedded, ferruginous. At the top, laminated, thin-bedded, evenly bedded, ferruginous sandstone layer 0.5 foot thick.........	6
3	Limestone, medium hard, evenly bedded, laminated with siltstone, thin-bedded, very pale orange (10YR 8/2)...	0.2
2	Marl, same as Unit 1, but less silt layers.........	1.2
	BASE OF K75 MARL MEMBER, TOP OF K71 FLAGGY LIMESTONE MEMBER	
1	Marl, friable to indurated, laminated, pale yellowish-orange (10YR 8/6) to dark yellowish-orange (10YR 6/6), evenly bedded, containing thin-bedded, laminated siltstone of the same color, interbedded with limestone flags. Limestone is hard, evenly bedded, thin-bedded (laminated) flaggy limestone, containing siltstone laminae, limestone beds are 0.2 foot to 0.4 foot thick...............................	3.9

Exposed thickness of K80 limestone	10	feet
Total thickness of K75 marl member	118	feet
Exposed thickness of K71 flaggy limestone member	4	feet
Total thickness of Measured Section 5	132	feet

Measured Section 6

K80 formation. Exposed in a landslide block one half mile north of stock pens by road at the head of Garrett Draw. Intermittent stream forms waterfall over the exposure. Beds strike N 53° W and dip 24° SW. NE¼NE¼ Sec. 5, Blk. 58, T. 9, T & P RR Co. Survey (Pl. II).

Unit		Thickness Feet
3	Limestone as in Unit 2 but medium- to thick-bedded; interbedded with marl as in Unit 1 but being slightly nodular; at the base of unit the thick beds of limestone are separated by thin beds of marl; the middle and upper portions of unit are formed of thick and medium beds of marl in equal proportions...........	40
2	Limestone, hard, evenly bedded, thin- to medium-bedded, very light gray (N8); much of it stained by limonite; weathered surface is chalky; interbedded with thin to medium beds of marl similar to that of Unit 1; proportion of shale decreases upward.......	27
1	Marl, indurated, thin-bedded, evenly bedded, medium light gray (N6) on fresh surface, pale yellowish-orange (10YR 8/6) on weathered surface.............	0.6

Total thickness of Measured Section 6 68 feet

Measured Section 7

Partial section of K90 marl and K90m chalky limestone member on the north side of Little Aguja Creek at the edge of the area on the Espy Ranch. NW$\frac{1}{4}$SE$\frac{1}{4}$ Sec. 26, Blk. 357 (Pl. II). (See Road Log 5). Dip S 70° W @ 7°.

Unit		Thickness Feet
9	Marl, soft, friable, pale olive (10YR 6/2) to pale yellowish-orange (10YR 8/6)........................	48
	TOP OF K90m CHALKY LIMESTONE MEMBER	
8	Marl, similar to the marl in lower beds, in beds up to 6 feet, interbedded with limestone as in Unit 5 in beds up to 3 feet..................................	30
	The bottom 18 feet are composed of marl interbedded with limestone and the top 12 feet are composed of limestone interbedded with marl. The limestone weathers into blocks and/or irregular, slabby fragments.	
7	Limestone, thick-bedded, evenly bedded, chalky and marly in places, impure, contains large _Inoceramus_ sp. interbedded with thin-bedded, friable, laminated marl as below up to 2 feet thick and thin beds of nodular, impure limestone of consistence of the thick beds. Forms prominent overhanging ledge. Limestone forms large rectangular blocks which form much talus at the bottom of the slope........................	15
6	Marl, soft, friable, blocky, thick-bedded, evenly bedded, pale yellowish-orange (10YR 8/6), fossiliferous, containing _Inoceramus_ prisms, plant roots, leaf imprints......................................	19
5	Limestone, very impure, medium-bedded, evenly bedded, yellowish-brown (10YR 6/2) to grayish-orange, easily fractured into slabs, blocky, containing ostrea fragments, many large and small _Inocerami_, leaf imprints, limonitic stains. Grades upward into Unit 6..............................	1
4	Marl, soft, friable, crumbly, silty, very thin-bedded, evenly bedded, laminated, grayish-yellow	

Unit		Thickness Feet
	(5Y 8/4) on fresh surface to pale yellowish-brown (10YR 6/2), fossiliferous, containing limonite stains, leaf imprints and pelecypod imprints. Numerous *Inoceramus* shell fragments and prisms......	13
3	Limestone, very impure, thick-bedded, chalky, dark gray (N3) to grayish black (N2) to pale yellowish-brown on fresh surface, weathers to grayish-orange (10YR 7/4). Upper portion is laminated, grading into marl of Unit 4. Weathering produces rectangular blocks which are easily fractured into slabs. Ledge-forming. Fossiliferous, containing ammonites and numerous large *Inoceramus* imprints and leaf imprints. *Peroniceras* sp...........................	6
2	Marl, friable to indurated, imperfectly laminated in thick beds, evenly bedded, calcareous, weathering slightly nodular and of the same color as Unit 1. Contains unevenly bedded and in places lenticular, indurated, nonlaminated, slightly ledge-forming marl beds up to 0.5 foot. Contains large *Inoceramus* sp..	32
1	Limestone, very impure, thin-bedded, medium-bedded, fresh surface medium light gray (N6), weathered surface very light gray (N8) to pale orange (10YR 8/2), soft to indurated, chalky, irregularly bedded. Weathered surfaces exposed on slope are fractured horizontally to form slabs and chips. Interbedded with marl similar to that of Unit 2. Limestone beds 1 foot to 1.5 feet, marl beds up to 0.8 foot...	6

BASE COVERED

Exposed thickness of upper K90 marl — 48 feet

Exposed thickness of K90m chalky limestone member — 122 feet

Total thickness of Measured Section 7 — 170 feet

Measured Section 8

K90 marl, partial section with no top or base exposed; above K90m chalky limestone member. Measured in creek bed just west of Washington Tank on KC Ranch, just upstream from small adobe shack. NE$\frac{1}{4}$SE$\frac{1}{4}$ Sec. 6, Blk. 57, T. 9, T & P RR Co. Survey (Pl. II). (See Road Log 4). Dip 26°.

Unit		Thickness Feet
11	Clay (same as Unit 7), but containing limestone septarian concretions..................................	45
10	Sand, slightly indurated, friable, cross-bedded, lenticular, silty, fine to very coarse-grained interbedded layers, containing chert pebbles and limonite concretions. Beds of fine silt to very coarse sand are interbedded........................	15
9	Clay, soft, plastic when wet, laminated, light gray (N7), containing interbeds of coarse-grained, sub-angular quartz sand................................	1
8	Siltstone, thin-bedded, loose, ferruginous, containing fine-grained sand, chert nodules up to 3 inches by 4 inches, and quartzite pebbles well-rounded up to 2 inches by 3 inches in size; shows slight wavy surface, and contains clay ironstone concretions....	0.2
7	Clay, soft, plastic when wet, light brown (5YR 5/6), silty; contains occasional silt layers 1 inch to 2 inches in thickness. Also contains brownish-orange streaks due to weathering of iron compounds to limonite. <u>Exogyra ponderosa</u>, <u>Glyptoxoceras</u> sp......	144
6	Limestone, medium hard to soft, thin-bedded, irregularly bedded, semi-nodular, sandy, impure, fossiliferous. Color same as Unit 4. <u>Inoceramus</u> sp., <u>Exogyra ponderosa</u>............................	2
5	Marl (same as Unit 1).............................	6
4	Limestone, hard, thin-bedded, irregularly bedded, chalky, impure, nodular, fossiliferous, grayish-orange (10YR 7/4) to pale greenish-yellow (10Y 8/2). Large <u>Inoceramus</u> imprints.........................	1.3

Unit		Thickness Feet
3	Marl (same as Unit 1). <u>Texanites</u> ? sp...............	4.5
2	Limestone, hard, dense, thin-bedded, irregularly bedded, nodular, impure, greenish-orange (10YR 7/4) to pale greenish-yellow (10Y 8/2), fossiliferous, containing fossil leaf imprints and oyster fragments. Large <u>Inoceramus</u> sp..................................	1
1	Marl, friable to soft, evenly bedded, slightly plastic when wet, fossiliferous, pale greenish-yellow (10Y 8/2) to dark yellowish-orange (10YR 6/6), containing orange splotches of limonite stain as a weathering product; globular calcitic geodes and flat platter-like geodes; secondary gypsum in veins that are randomly oriented and an abundance of gypsum crystals that weather out loose................................	10

BASE COVERED

Exposed thickness of K90 marl 230 feet

Total thickness of Measured Section 8 230 feet

Measured Section 9

K100 formation. Prominent scarp on the east bank of Little Aguja Creek 4 miles north of Star Mountain; scarp formed of black shale and capped by Star Mountain rhyolite. To reach this section, enter via the Jimmy Duncan, Jr. ranch road and follow jeep road leading south for 3 miles. Measured up scarp face 500 yards east of road. NE$\frac{1}{4}$SE$\frac{1}{4}$ Sec. 15, Blk. 56, T. 10, T & P RR Co. Survey (Pl. II). (See Road Log 6).

Unit		Thickness Feet
5	Shale, indurated to friable, thin- to thick-bedded, irregularly bedded, lenticular, carbonaceous, crumbly, blocky, containing limonite nodules. Color same as below. Forms thick ledge underlying contact with Star Mountain rhyolite. _Gryphaea_ sp., _Inoceramus_ prisms..	22
4	Limestone, hard, medium-bedded, evenly bedded, lenticular, chalky, petroliferous, carbonaceous, oolitic, color same as Unit 1, containing fossil imprints, limonite splotches..........................	2.7
3	Shale, thin- to thick-bedded, consisting of alternating beds similar to those of Units 1 and 2. Beds like Unit 1 forming conspicuous ledges; beds like Unit 2 forming slopes................................	40
2	Shale, thick-bedded, evenly bedded, color as in Unit 1. Weathers into fine paper-like flakes which tend to cover the slope................................	11
1	Shale, indurated to friable, evenly bedded, thick-bedded to medium-bedded, fresh surface olive gray (5Y 4/1) to dark gray (N3) and slightly petroliferous, weathered surface medium light gray (N6). Contains _Inoceramus_ sp. Forms slope which is terminated in creek bottom..	7

Exposed thickness of K100 formation 83 feet

Total thickness of Measured Section 9 83 feet

Measured Section 13

Upper part of nodular member of *Kent Station limestone and basal part of Buda limestone. Location: On north side of draw upstream from earthen tank, northeast of KC Ranch house approximately 2 miles. NW$\frac{1}{4}$NE$\frac{1}{4}$ Sec. 13, Blk. 58, T. 9, T & P RR Co. Survey (Pl. II). (See Road Log 2). Strike N 65° E; Dip 3°.

Unit		Thickness Feet
7	Limestone, clastic, hard, reefy, medium-bedded, evenly bedded, yellowish-gray (5Y 8/1) to pale yellowish-orange (10YR 8/6), fossiliferous, oolitic, flashing surfaces of calcite. Forms cap on hill. Weathers to a pale yellowish-brown (10YR 6/2) and forms rectangular to irregular blocks having a pitted surface due to solution. Pits range in size from 0.01 foot to 0.03 foot in diameter and up to 0.1 foot deep. Weathered blocks show dessication cracks and ring when struck with hammer. Large joints 1 foot to 2 feet wide, filled with soil, in limestone bed capping hill trend N 45° W. Secondary fractures trend N 50° E....................................	8
6	Limestone, medium hard, medium-bedded, irregularly bedded, nodular, yellowish-gray (5Y 7/2), forms steep slope. _Tylostoma_ sp............................	20
5	Sandstone, calcareous (sandy limestone ?), hard, moderate brown (5YR 4/4), fine to very fine, pepper-speckled, slightly glauconitic, richly fossiliferous. Medium-bedded, angular to subangular; grades into a sandy limestone on top bed. Weathers to a dark yellowish-brown (10YR 4/2). Lower 3 feet covered, upper ledge well exposed............................	9
4	Covered and forming slight bench....................	17
	BASE OF LOWER MEMBER OF BUDA LIMESTONE, TOP OF NODULAR MEMBER OF *KENT STATION LIMESTONE	
3	Limestone, hard, dense, thin- to medium-bedded, flashing with tiny calcite crystals, fossiliferous, slightly oolitic in places, yellowish-gray (5Y 7/2) to grayish-orange (10YR 7/4), weathers to a flaggy surface and forms a moderate slope..................	18

Unit		Thickness Feet
2	Limestone, hard, dense, flashing with large calcite crystals, medium- to thick-bedded, pale yellowish-orange (10YR 8/6) to white (N9), reefy, fossiliferous, slightly oolitic and containing limonite spots. Weathers into large rectangular blocks of a light olive gray (5Y 6/1) showing dessication cracks and schratten weathering and etched potholes due to solution..	6
	BASE OF K50 LIMESTONE (Taylor, 1952)	
1	Limestone, hard, medium, irregularly bedded, yellowish-gray (5Y 7/2), nodular, fossiliferous, slightly limonitic and contains few small calcite crystals. Weathers to a moderate yellow and forms a rough, irregular, ledgy bench. _Cymatoceras_ sp. 10 feet below top. _Cymatoceras_ _texanum_ (Shumard), _Pecten_ sp., _Pecten_ (_Neithea_) _texanus_ (Roemer), _Tylostoma_ _kentense_ (Stanton), gastropods...........	10

Exposed thickness of Buda limestone	54 feet
Exposed thickness of *Kent Station limestone	34 feet
Total thickness of Measured Section 13	88 feet

Measured Section 14

Measured section of KC sandstone member of Buda limestone.
Location: West of the Lethco Ranch house approximately one-half mile. SW$\frac{1}{4}$SW$\frac{1}{4}$ Sec. 46, Blk. C13, PSL Survey (Pl. II). (See Road Log 1).

Unit		Thickness Feet
	TOP OF KC SANDSTONE MEMBER	
4	Sandstone, hard, calcareous, limonitic, moderate yellowish-brown (10YR 5/4), quartz, pepper-speckled, slightly fossiliferous, but only in the form of fragments...	0.5
3	Limestone, dense, thick to evenly bedded, slightly sandy and increasingly sandy near the top of unit, flashing calcite crystal faces. Color essentially the same as below, but much less limonitic. The sand grains more apparent on the weathered surface than on fresh surface. Weathers to a pitted surface and contains many fragments which have been replaced by chert. Sand fine-grained; weathered surface feels like sandpaper.......................................	2
2	Limestone, medium hard, sandy, irregularly bedded, thin- to medium-bedded, reefy, containing numerous pelecypod shell fragments, medium yellowish-orange (10YR 7/6); in places tending to be nodular, containing fine quartz sand, very limonitic and containing much caliche............................	8
	BASE OF KC SANDSTONE MEMBER, TOP OF LOWER MEMBER	
1	Limestone, hard, dense, reefy, thick-bedded, fresh surface contains many pinpoint flashing surfaces, very pale orange (10YR 8/2), sparsely limonitic, uneven fracture, cherty in places, fossil fragments numerous and unidentifiable, probably largely algal material. Weathered surface contains many solution pits, some up to 2 inches deep. Color is pale yellowish-orange (10YR 8/6) to dusky brown (5YR 2/2), contains joints trending N 45° W...	16
	BASE OF BUDA LIMESTONE	

Total thickness of KC sandstone member	11 feet
Total thickness of lower limestone member	16 feet
Exposed thickness of Buda limestone	27 feet
Total thickness of Measured Section 14	27 feet

Measured Section 15

Upper part of nodular member of *Kent Station limestone and entire section of Buda limestone. Location: Just northwest of sink in deep draw on KC Ranch. NW¼SW¼ Sec. 7, Blk. 57, T. 9, T & P RR Co. Survey (Pl. II). (See Road Log 2).

Unit		Thickness Feet
	TOP OF BUDA LIMESTONE	
12	Limestone, hard, reefy, medium-bedded, fossiliferous, flashing pinpoint surfaces of calcite, white (N9) on fresh surface to grayish-yellow (5Y 8/4). Weathered surface light olive gray (5Y 5/2). Weathers into thick irregular blocks up to 2 feet thick showing dessication cracks, but not as abundant as in Unit 6. *Pecten roemeri* Hill, *Nerinea volana* (Cragin), silicified corals, solitary and colonial. Top of hill..	6
11	Limestone, dense, medium-bedded to thick-bedded, nodular, yellowish-gray (5Y 7/2) on fresh surface, containing lenses and nodules of chert up to 2 feet long, flashing with calcite crystals. Weathers to pale yellowish-orange (10YR 8/6). Chert on fresh surface predominantly light olive gray (5Y 6/1) to varicolored. Limestone contains fossils and animal borings...	29
10	Limestone, hard, dense, medium-bedded to thick-bedded, evenly bedded (same as Unit 6, Measured Section 3). Forms rough, irregular slope with numerous ledges. Much chert in float..............	9
9	Limestone, hard, dense, thick- to medium-bedded, flaggy, (same as Unit 5, Measured Section 3)........	16
8	Limestone, hard, thin-bedded, irregularly bedded (same as Unit 4, Measured Section 3). Forms slope of nodular material and with much chert in float....	16
	BASE OF UPPER MEMBER, TOP OF KC SANDSTONE MEMBER	
7	Sandstone, medium- to thin-bedded, calcareous, fossiliferous, pepper-speckled, fine-grained, angular	

Unit		Thickness Feet
	to subangular quartz. Color on fresh surface grayish-orange (10YR 6/6), weathered surface moderate yellowish-brown (10YR 5/4). Weathered fragments partially coated with caliche. Sand grades upward into sandy limestone containing many large flashing surfaces of calcite and some manganese dendrites. (Forms bench above massive limestone of lower member of Buda)................................	6
	BASE OF KC SANDSTONE MEMBER, TOP OF LOWER MEMBER	
6	Limestone, thick-bedded, reefy, white (N9) tinged with splotches of moderate yellow (5Y 7/6) slightly oolitic, limonitic, calcite flashing surfaces. Weathers to yellowish-gray (5Y 7/2); surface pitted with solution holes and grooves. Lower 4 feet containing iron stains and lenses......................	16
	BASE OF BUDA LIMESTONE, TOP OF *KENT STATION LIMESTONE	
5	Limestone, hard, dense, unevenly bedded, fossiliferous, pinpoint flashing surfaces. Fresh surface dusky yellow (5Y 6/4), weathered surface yellowish-gray (5Y 7/2); this unit contains echinoids and <u>Gryphaea</u> sp. at other localities............................	7
4	Limestone, hard, dense, medium- to thick-bedded, many pinpoint flashing surfaces, fresh surface yellowish-gray (5Y 7/2), weathered slope covered with many angular blocks up to 0.8 foot by 0.5 foot...........	17
3	Limestone, hard, dense, thin- to medium-bedded, pinpoint flashing surfaces, fresh surface yellowish-gray (5Y 7/2) to pale olive (10Y 6/2). Slight break in slope at top of this unit.......................	9
2	Limestone, dense, evenly bedded, thick-bedded, pinpoint flashing surfaces, fresh surface yellowish-gray (5Y 7/2), weathered surface moderate yellow (5Y 7/6). Top bed forms prominent shelf, is the thickest bed in the unit and contains solution pits and grooves...	10
1	Limestone, irregularly bedded, medium- to thick-	

Unit		Thickness Feet
	bedded, nodular, dense, pinpoint flashing surface, fresh surface very pale orange (10YR 8/2), weathered surface yellowish-gray (5Y 7/2)......................	8

Total thickness of Buda limestone	98 feet
Exposed thickness of *Kent Station limestone	51 feet
Total thickness of Measured Section 15	149 feet

Measured Section 16

Partial section of K90m chalky limestone member of K90 marl. Location: At head of small draw three-fourths mile northwest of Little Aguja Peak. SW$\frac{1}{4}$SE$\frac{1}{4}$ Sec. 23, Blk. 57, T. 10, T & P RR Co. Survey (Pl. II).

Unit		Thickness Feet
3	Marl, same as Unit 1..................................	10
2	Limestone, medium hard, medium- to thin-bedded, evenly bedded, slabby, impure, chalky, fossiliferous, very pale orange (10YR 8/2) to pale yellowish-orange (10YR 8/6); contains large Inoceramus prisms and shell fragments. Limestone is interbedded with thin marl beds similar to those in Unit 1. Marl beds are 0.2 to 0.5 foot thick and limestone beds average 1.5 feet in thickness. Ammonites 14 feet from base. Limestone ledges weather into irregular flat slabs and chips. Texanites sp..................................	44
1	Marl, evenly bedded, friable to indurated, laminated, chalky, very pale orange (10YR 8/2) to pale yellowish-orange (10YR 8/6); deeply weathered, base not exposed..	7

Exposed thickness of K90m chalky limestone member 61 feet

Total thickness of Measured Section 16 61 feet

Measured Section 17

Outcrop of K80 limestone just south of J. C. Duncan Ranch house near a windmill and tank. $SW\frac{1}{4}NW\frac{1}{4}$ Sec. 11, Blk. 57, T. 10, T & P RR Co. Survey (Pl. II). (See Road Log 6).

K90 MARL

Soft, friable, laminated, fossiliferous, chalky marl; pale yellowish-orange (10YR 8/6) to very pale orange (10YR 8/2). Badly weathered.

Unit		Thickness Feet
	BASE OF K90 MARL, TOP OF K80 LIMESTONE	
1	Limestone, hard, dense, chalky, thin-bedded to medium-bedded, evenly bedded, nodular, yellowish-gray (5Y 8/1), containing abundant <u>Inoceramus</u> sp. and secondary limonite stains; interbedded with marl, pale greenish-yellow (10YR 8/2), evenly bedded, laminated and containing much caliche. Limestone layers are 1.0 foot to 1.5 feet in thickness and marl layers vary in thickness from 0.5 foot to 2 feet. Weathers to form a surface covered with small, irregular chips varying in size from 0.2 foot by 0.05 foot to 0.5 foot by 0.3 foot. <u>Prionocyclus</u> spp., <u>Collignoniceras</u> sp. [<u>Prionotropis</u> <u>woolgari</u> (Meek)] 20 feet from base of section. <u>Prionocyclus</u> sp. aff. <u>P. wyomingensis</u> (Cobban). Base covered............	50

ROAD LOGS

Road Log 1

To Measured Sections 1, 6 and 14. Along U. S. Highway 290 from Toyahvale toward Davis Mountain Station.

Miles	Landmark
0.0	Intersection of State Highway 17 and U. S. Highway 290 (1 mile west of Toyahvale). (Take-off for Road Log 5).
3.5	Cattleguard to Madera Canyon Road (9.5 miles west to Duncan Kingston Ranch). (Take-off for Road Log 6).
5.0	Jeff Davis-Reeves County Line.
6.7	Draw.
8.8	Gate to Cherry Canyon Ranch Road (to Morris and McElroy Ranches). (Take-off for Road Log 3).
9.9	Reeves-Jeff Davis County Line.
10.2	Gate to KC Ranch. (Take-off for Road Log 2).
12.0	Garrett Draw. (Take-off for Road Log 4).
13.2	Gate to Lethco Ranch. Turn left through gate.
13.5	Windmill on right (on KC property).
15.3	Iron gate into Lethco Ranch.
16.3	Measured Section 1 (on left side of road).
17.1	Lethco Ranch house.
18.4	Leave road and pack approximately $\frac{1}{4}$ mile northwest to Buda outcrop on top of ridge. Measured Section 14. Continue along this road to ranch corrals, thence northwest unmeasured distance to Measured Section 6 in Sec. 5, Blk. 58, T. 9, T & P RR Co. Survey.

Road Log 2

To Measured Sections 3, 4, 5, 13, and 15.

Miles	Landmark
0.0	Gate to KC Ranch.
0.6	Windmill and tank on right.
3.7	Wooden gate.
4.5	Turn very sharp to the left on ranch trail. Continue along this trail approximately 1.0 mile through two wire gaps to Dry Tank on KC Ranch and Measured Section 4.
	Return to road.
4.55	Turn left on ranch trail. Continue along this trail approximately 1.0 mile through two wire gaps. Second gap is on corner of Secs. 13, 18, 19, and 24, Blk. 58, T. 9, T & P RR Co. Survey. Thence, pack 0.2 mile (estimated) east to Measured Section 5.
	Return to road.
5.2	Turn sharp right on ranch trail. Continue approximately 1¼ miles along trail to mouth of draw.
6.5	Turn left and proceed up draw approximately 3/4 mile to Measured Section 13.
	Return to trail.
7.3	Wire fence near mouth of draw. Turn left and proceed updraw approximately 0.7 mile to Measured Section 15.
	Return to trail.
7.7	Trail continues through wire gap toward the east. Take dim trail along south bank of Rattlesnake Draw and continue approximately ½ mile to Measured Section 3.

Road Log 3

To Measured Section 2 and Fossil locality 1.

Miles	Landmark
0.0	Gate to Cherry Canyon Ranch road. Turn left through gate. Continue west along ranch road.
3.1	At this point Cherry Draw can be seen approximately 200 yards to the north of the road. Pack towards a steep cliff in north bank of Cherry Draw. Measured Section 6 begins at base of this cliff.
	Leave road and pack approximately $\frac{1}{2}$ mile southeast to Fossil locality 1 and silicified fossils in Sec. 33, Blk. 57, T. 9, T & P RR Co. Survey.

Road Log 4

To Measured Section 8.

Miles	Landmark
0.0	Gate to Lethco Ranch (See Road Log 1). Turn sharp left after entering gate and continue on dim trail along wire fence.
0.4	Trail turns southwest away from fence.
1.5	Cross Garrett Draw.
2.1	Old adobe house.
2.2	Start of Measured Section 8 in stream bed.

Road Log 5

To Measured Section 7.

Miles	Landmark
0.0	Intersection of State Highway 17 and U. S. Highway 290, 1 mile west of Toyahvale.
7.0	Boy Scout Road. Turn right.
11.4	Cross cattleguard at Jim Duncan Ranch house.
12.5	Cross cattleguard on Duncan-Espy line.
13.6	Cross cattleguard.
13.9	Cross cattleguard. Espy Ranch house to south.
14.8	Curve in road. Pack $\frac{1}{2}$ mile northwest to yellow cliff in north bank of Little Aguja Creek. Measured Section 7.

Road Log 6

To Measured Sections 9 and 17.

Miles	Landmark
0.0	Cattleguard at intersection of Madera Springs Road and U. S. Highway 290.
6.0	Cross cattleguard. Turn left on road to Jim Duncan Ranch.
6.9	Corral on south side of road.
7.5	Jim Duncan Ranch house. Continue through wire gap near corrals on dim trail.
7.9	K80 outcrop near NW-SE fence. Measured Section 17.
	Continue along dim trail approximately 3 miles to Black Cliffs.
10.9	Leave trail and go approximately 500 yards east of trail to east bank of Little Aguja Creek and steep cliffs of black shale. Black Cliffs. Measured Section 9 was taken up this cliff face.


GEOLOGY
OF
NORTHEASTERN FRONT
OF DAVIS MOUNTAINS
JEFF DAVIS COUNTY TRANS-PECOS, TEXAS
MAPPED BY
JESSE L. BRUNDRETT JOE O. WHEELER
SUMMER 1953
Supervised by
R.K. DeFord
J.P. Brand
Department of Geology The University of Texas
Map Printed May 1954
COMPOSITE SECTION OF EXPOSED CRETACEOUS
petroliferous limestone and shale
carbonaceous shale with septarian-bearing limestone beds
carbonaceous shale
nodular impure limestone
reefy and clastic limestone
nodular limestone
QUATERNARY SYSTEM
Qca Calamity alluvium
Qn Neville alluvium
Qgo Gozar gravel
Qls Landslide debris
Qnm Ninemile gravel
Q50 Q50 gravel
TERTIARY SYSTEM
McCutcheon Group
Tu volcanic formations, age undetermined, partly younger than Star Mountain rhyolite
Tsm T40 Star Mountain rhyolite; T40 rhyolite (Taylor, 1952) on north, tentatively correlated with basal part of Star Mountain rhyolite
Th Thl Huelster tuff, with non-marine limestone member
T30 T30 basalt
Tj Jeff conglomerate
CRETACEOUS SYSTEM
Gulf Series
K100 K100 formation
K90 K90m K90 marl with K90m chalky limestone member
K80 K80 limestone
K75 K71 Boquillas formation with K75 marl member and K71 flaggy limestone member
Comanche Series
Kbu KC Buda limestone with KC sandstone member
Kkn Kkf Kent Station limestone with nodular member and fossiliferous member (after Taylor, 1952)
known, concealed, and inferred normal fault
anticlinal axis
synclinal axis
measured section 4
x 3543 USC&GS bench mark, elevation 3,543 feet above sea level
Δ 6390 USC&GS triangulation station, elevation 6,390 feet above sea level
abandoned building-stone quarry
wire fence
windmill
metal tank
earthen tank
ranch road
trail passable by pickup truck
cross in copper disk set in concrete post by KC Ranch to mark common corner of sections 31, 42, 36 and 37
fossil locality 2
Scale
MEAN DECLINATION 1954
REEVES
JEFF DAVIS
COUNTY
COUNTY
Red Hills
Newman Peak
Bear Canyon
Cherry Draw
Dark Canyon
Timber Mountain
Bear Mountain
Star Mountain
Little Aguja Draw

PLATE II

The vita has been removed from the digitized version of this document.